Draft Environmental Statement of the Island Park Geothermal Area

Idaho • Montana • Wyoming

United States Department of Agriculture
Forest Service

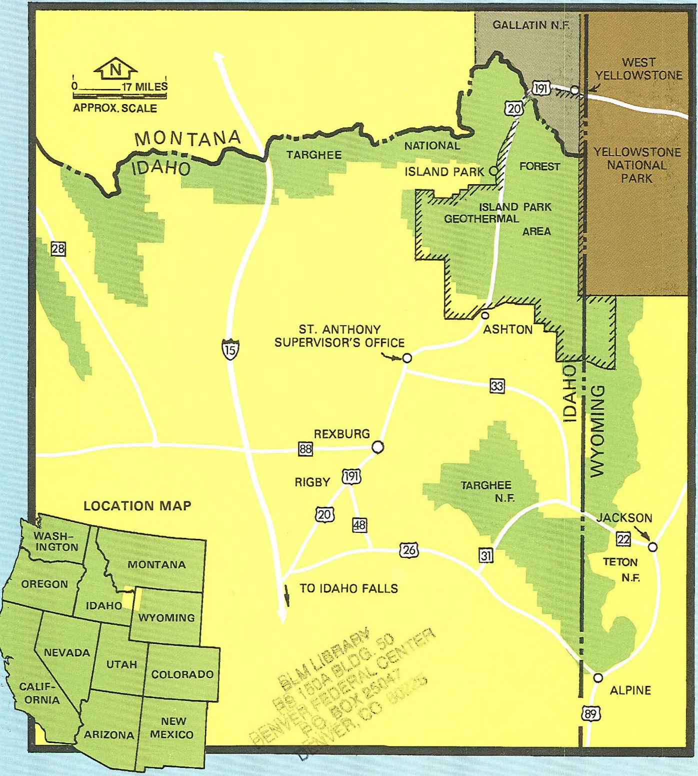
United States Department of the Interior
Bureau of Land Management

ISLAND PARK GEOTHERMAL AREA

FREMONT CO. - GALLATIN CO. - TETON CO.

IDAHO - MONTANA - WYOMING

FOREST SERVICE & BUREAU OF
LAND MANAGEMENT



DRAFT ENVIRONMENTAL STATEMENT

01-15-79-02

LEASING AND DEVELOPMENT
ISLAND PARK GEOTHERMAL AREA

LEAD AGENCY:

USDA—FOREST SERVICE
INTERMOUNTAIN REGION
324 - 25th STREET
OGDEN, UT 84401

COOPERATING AGENCIES:

USDA—FOREST SERVICE
NORTHERN REGION
FEDERAL BUILDING
MISSOULA, MT 59807

USDI—BUREAU OF LAND MANAGEMENT
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BOISE, ID 83724

USDI—FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
4620 OVERLAND RD.
BOISE, ID 83705

USDI—U.S. GEOLOGICAL SURVEY
CONSERVATION DIVISION & WATER
RESOURCES DIVISION
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MENLO PARK, CA 94025

USDI—NATIONAL PARK SERVICE
YELLOWSTONE NATIONAL PARK
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ST. ANTHONY, ID 83445
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ABSTRACT: This draft environmental statement describes six alternatives for leasing 488,031 acres of Federal lands in Idaho, Montana and Wyoming. The statement describes the estimated effects of a geothermal leasing program by the various alternatives. A preferred alternative has not been selected. Public comment is requested on the alternatives and the proposed decision criteria.

SEND COMMENTS TO:

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COMMENTS MUST BE RECEIVED BY: MAY 21 1979

SUMMARY

DRAFT ENVIRONMENTAL STATEMENT

LEASING AND DEVELOPMENT

ISLAND PARK GEOTHERMAL AREA

04-15-79-02

ADMINISTRATIVE ACTION

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Date of Transmission to
EPA and the Public: MAR 21 1979

I. This draft environmental statement considers the effects of geothermal leasing and development on 488,031 acres of public land in Idaho, Montana and Wyoming administered by two Federal agencies: the USDA—Forest Service and the USDI—Bureau of Land Management. The lands considered are known collectively as the Island Park Geothermal Area (IPGA) and contain two areas classified as "Known Geothermal Resource Areas" (KGRA) by the U.S. Geological Survey.

Approximately 200 lease applications have been received for geothermal exploration and development within the Island Park Geothermal Area. These applications are outside the two designated Known Geothermal Resource areas and would be leased non-competitively if leasing is approved.

Major considerations of a geothermal leasing program within the Island Park Geothermal Area include:

—Potential effects on surface and groundwater resources.

—Potential effects on threatened and/or endangered wildlife species.

—Proximity to Yellowstone National Park and its surface hydrothermal features.

—Economic and social effects.

II. Alternative approaches considered in this environmental statement include:

Alternative 1—No leasing.

Alternative 2—Leasing as proposed by participants of the public workshop.

Alternative 3—Lease a portion of the area. Defer leasing on a portion and refuse leasing on some of the lands.

Alternative 4—Lease most of the area, but much of the available lands would be restricted to no surface occupancy restrictions. A small portion would be deferred (RARE II).

Alternative 5—Allow leasing on a large portion of the area, but restrict some of this to surface occupancy restrictions, i.e. use of existing roads, use of portable drilling rigs. Defer those areas being considered in the RARE II process. Deny leasing on environmentally sensitive lands.

Alternative 6—Lease the entire area.

III. Environmental effects

Cause	Potential Effects
Exploration and Development	Increased employment relative to the extent of discovery and development
Development of Resource	Additional energy for electricity, space heating and other industrial/ agricultural uses
Operation of Facilities	Air pollution from geothermal gases Increased noise and objectionable odors Local climatic modifications Royalty payments and rent to Federal Government
Construction and Development	Soil erosion and possible mass failures Increased man-caused wildfires Reduced visual quality Destruction of vegetation Improved access Reduction in timber production Increased noise levels Stream habitat modification Conflict with recreational pursuits Obliteration of archaeological/historical sites Air pollution from dust and debris burning Increased traffic and road maintenance Increased tax base for affected counties Displacement and disturbance of wildlife Possible water degradation from spills, blowouts or casing failures Social and economic stress from increased population Modification of wildlife habitat
Environmental Studies	Additional resource data for future management decisions

IV. Written comments to this draft environmental statement have been requested from the following agencies, organizations, officials and individuals:

FEDERAL AGENCIES

Action
Advisory Council on Historic Preservation
Central Intelligence Agency
Department of Agriculture

- Agricultural Research Service
- Agricultural Stabilization and Conservation Service
- Farmers Home Administration
- Forest Service
- Office of Equal Opportunity
- Office of the General Counsel
- Office of the Secretary
- Rural Electrification Administration
- Soil Conservation Service

Department of Commerce
Department of Defense
Department of Energy
Department of Health, Education and Welfare
Department of Housing and Urban Development
Department of the Interior
Environmental Protection Agency
Federal Energy Regulatory Commission
Federal Highway Administration
General Services Administration
Interstate Commerce Commission
Missouri River Basins Commission
Nuclear Regulatory Commission
Office of Economic Opportunity
Pacific Northwest River Basins Commission
Water Resources Council

STATE AND LOCAL AGENCIES

STATE OF IDAHO

Attorney General's Office
Bureau of Mines and Geology
Bureau of State Planning and Community Affairs
Department of Agriculture
Department of Education
Department of Employment
Department of Health and Welfare, Division of Environment
Department of Lands
Department of Parks and Recreation
Department of Water Resources
Division of Budget Policy Planning and Coordination
Division of Tourism and Industrial Development
Fish and Game Department
Harriman State Park
Historic Preservation Officer
Office of Energy
Public Utilities Commission
Southeast Idaho Council of Governments
State Archaeologist
State Coordinator of Federal Programs
State Historical Society
Transportation Department
Water Resources Board

LOCAL

Fremont County Board of Commissioners, St. Anthony

STATE OF MONTANA

Bureau of Mines and Geology
Department of Agriculture
Department of Community Affairs
Department of Health
Department of Intergovernmental Relations, Economic Development Division
Department of Lands
Department of Natural Resources and Conservation
Environmental Quality Council
Fish and Game Department
Governor's Office
Historic Preservation Officer

LOCAL

Gallatin County Board of Commissioners, Bozeman

STATE OF WYOMING

Commission of Public Lands and Farm Loans
Department of Agriculture
Department of Economic Planning and Development
Department of Environmental Quality
Energy Conservation Office
Game and Fish Department
Highway Department
Industrial Siting Administration
Land Use Administration
Recreation Commission
State Engineer's Office
State Planning Office
Wyoming Geological Survey

LOCAL

Teton County Board of Commissioners, Jackson

ELECTED OFFICIALS

IDAHO

U.S. Senator Frank Church, Washington, D.C.
U.S. Senator James McClure, Washington, D.C.
U.S. Representative George Hansen, Washington, D.C.
John V. Evans, Governor, Boise
Mark Ricks, Senator, Boise
Mel Hammond, Representative, Boise
Doyle Miner, Representative, Boise

MONTANA

U.S. Senator Max Baucus, Washington, D.C.
U.S. Senator John Melcher, Washington, D.C.
U.S. Representative Pat Williams, Washington, D.C.
Thomas L. Judge, Governor, Helena
Mike Anderson, Senator, Helena
Paul Boylan, Senator, Helena
Robert A. Ellerd, Representative, Helena
Dr. Everett R. Lensink, Senator, Helena
Kenneth L. Nordtvedt, Jr., Representative, Helena
Walter R. Sales, Representative, Helena
John P. Scully, Representative, Helena
John Vincent, Representative, Helena

WYOMING

U.S. Senator Allan Simpson, Washington, D.C.
U.S. Senator Malcolm Wallop, Washington, D.C.
U.S. Representative Dick Cheney, Washington, D.C.
Ed Herschler, Governor, Cheyenne
H.L. Jensen, Representative, Cheyenne
John Turner, Senator, Cheyenne

ORGANIZATIONS

Amax Exploration, Inc.
Helena, MT

American Falls Trail Machine Assn.
American Falls, ID

American Forest Institute
Portland, OR

American Smelting and Refining Company
Salt Lake City, UT

Ammon Drift Riders
Idaho Falls, ID

The Anschutz Corporation
Denver, CO

Archery Club, Wapiti
Idaho Falls, ID

Ashton Herald
Ashton, ID

Association of Idaho Cities
Boise, ID

Asso. Taxpayers of Idaho
Boise, ID

Audubon Society
Bozeman, MT

Big Sky of Montana
Big Sky, MT

Bombardier West
Idaho Falls, ID

Bonneville County Parks & Recreation Planner
Idaho Falls, ID

Bonneville Power Admin.
Idaho Falls, ID

Bonneville Sportsman Assoc.
Idaho Falls, ID

Bozeman Chamber of Commerce
Bozeman, MT

Bozeman Chronicle
Bozeman, MT

California Geothermal, Inc.
San Diego, CA

Center for the Public Interest
Bozeman, MT

Chamber of Commerce
Ashton, ID

Chamber of Commerce
Blackfoot, ID

Chamber of Commerce
Idaho Falls, ID

Chamber of Commerce
Rexburg, ID

Chamber of Commerce
Rigby, ID

Chamber of Commerce
St. Anthony, ID

Chamber of Commerce
West Yellowstone, MT

Chevron Oil Co.
Denver, CO

Chevron Resource Co.
San Francisco, CA

Citizens Coalition
Pocatello, ID

Clark County Snowrunners
Dubois, ID

Council of Six
Thornton, ID

Delta Funds, Inc.
Philadelphia, PA

Diamondback Cycle Club
Pocatello, ID

Eagle Rock Long Rifles
Idaho Falls, ID

East Central ID Planning Div. Assoc.
Rexburg, ID

East-Side Forest Practices Committee
Belgrade, MT

Edward Hines Lumber Co.
St. Anthony, ID

El Paso Natural Gas Company
El Paso, TX

Environmental Quality Committee
League of Women Voters
Rigby, ID

Environmental Science & Engineering Inc.
St. Louis, MO

Environmental Sciences Div.
Stearns-Roger Inc.
Denver, CO

Fall River Electric
Island Park, ID

Fall River REA
Ashton, ID

Fall River Rural Electric Cooperative, Inc.
Ashton, ID

Fall River Electric Co-op
West Yellowstone, MT

Family Trail Riding Assoc.
Idaho Falls, ID

Farm Bureau
Boise, ID

Farm Bureau
St. Anthony, ID

Federal Timber Purchasers Assoc.
Denver, CO

Federation of Western Outdoor Clubs
Idaho Falls, ID

FHWA Division Admin.
Helena, MT

Forsgren and Perkins
Rexburg, ID

Forsgren and Perkins Assoc., P.A.
Salt Lake City, UT

Fremont Cattlemen's Assoc.
Rexburg, ID

Fremont County Chronicle News
St. Anthony, ID

Fremont Outdoor Education & Recreation, Inc.
St. Anthony, ID

FRIENDS OF THE EARTH
Missoula, MT

Gallatin Canyon Summer Home Assn.
Bozeman, MT

Gallatin Canyon Women's Club
Gallatin Gateway, MT

Gallatin Sportsmen's Assn.
Belgrade, MT

Gallatin Canyon Recreation & Wildlife Assoc.
Gallatin Gateway, MT

Gallatin Wildlife Assoc.
Bozeman, MT

Garland Call Pole Company
Idaho Falls, ID

General Crude Oil Co.
Houston, TX

Gulf Oil Corporation
Denver, CO

Hanna Mining Company
Salt Lake City, UT

Hawthorn Oil Company
Casper, WY

H.T.H. Corp.
Parker, ID

Humble Oil and Refining Co.
Denver, CO

Idaho Alpine Club
Idaho Falls, ID

Idaho Association of Commerce & Industries
Boise, ID

Idaho Cattlemen's Assoc.
Boise, ID

Idaho Cattlemen's Assoc.
St. Anthony, ID

Idaho Conservation League
Boise, ID

Idaho Environmental Council
Idaho Falls, ID

Idaho Falls Federated Women's Club
Idaho Falls, ID

Idaho Falls Motorcycle Club
Idaho Falls, ID

Idaho Falls Ski Club
Idaho Falls, ID

Idaho Falls Sno-Snoopers
Idaho Falls, ID

Idaho Falls Snowmobile Club
Idaho Falls, ID

Idaho Farmer and Stockman
Boise, ID

Idaho Forest Industry Council
Coeur d'Alene, ID

Idaho Free Press
Nampa, ID

Idaho Gem Club
Boise, ID

Idaho League of Women Voters
Idaho Falls, ID

Idaho Falls Snowmobile Club
Idaho Falls, ID

Idaho Farmer and Stockman
Boise, ID

Idaho Forest Industry Council
Coeur d'Alene, ID

Idaho Free Press
Nampa, ID

Idaho Gem Club
Boise, ID

Idaho League of Women Voters
Idaho Falls, ID

Idaho Mining Assoc.
Boise, ID

Idaho Outfitters & Guides Assoc.
Boise, ID

Idaho Outfitters & Guides Assoc.
Salmon, ID

Idaho Outfitters & Guides Board
Boise, ID

Idaho Power Company
Boise, ID

Idaho Resources Development Council
Boise, ID

Idaho Snowmobile Assoc.
Idaho Falls, ID

Idaho State Automobile Assoc.
Boise, ID

Idaho State Historical Society
Boise, ID

Idaho State Journal
Pocatello, ID

Idaho State Snowmobile Assoc.
Twin Falls, ID

Idaho Water Users Assoc.
Boise, ID

Idaho Wildlife Federation
Idaho Falls, ID

Idaho Wool Growers Assoc.
Burley, ID

Island Park Chamber of Commerce
Island Park, ID

Island Park Sportsman Assoc.
Mack's Inn, ID

Isaac Walton League
Laramie, WY

ISU Outdoor Program
Pocatello, ID

ISU Wilderness Club
Pocatello, ID

Jackson Hole Chamber of Commerce
Jackson, WY

Jackson Hole Mountain Guides
Teton Village, WY

KBMN Radio News
Bozeman, MT

KBOZ
Bozeman, MT

KID Radio News
Idaho Falls, ID

KIFI Television News
Idaho Falls, ID

KIGO Radio News
St. Anthony, ID

Kiwanis West
Idaho Falls, ID

KMTN-FM Radio News
Jackson, WY

KSGT Radio
Jackson, WY

KWYS
West Yellowstone, MT

KXXL Radio News
Bozeman, MT

League of Women Voters
Blackfoot, ID

League of Women Voters
Idaho Falls, ID

Limnetics, Inc.
Denver, CO

McDowell, Scott and Cox, Inc.
Boulder, CO

Midwest/Rocky Mtn. Team DSC
Denver, CO

Montana Dude Ranchers Assoc.
Gallatin Gateway, MT

Montana Historical Society
Helena, MT

Montana Power Company
Butte, MT

Montana Travel Incorporated
Bozeman, MT

Montana Wilderness Assoc.
Bozeman, MT

Mountain States Tel. & Tel. Co.
St. Anthony, ID

National Forest Products Assoc.
Washington, D.C.

National Wildlife Federation
Washington, D.C.

NPA Newsletter & Courier
Washington, D.C.

NUS Corporation
Pittsburg, PA

Oregon Shortline Railroad
Salt Lake City, UT

Outdoors Unlimited Inc.
Ogden, UT

Pocatello Chamber of Commerce
Pocatello, ID

Pocatello Trail Machine Assoc.
Pocatello, ID

REMSI
Laramie, WY

Rexburg Lumber Company
Rexburg, ID

Rexburg Standard Journal
Rexburg, ID

Richey & Sons
Ashton, ID

Sierra Club
Seattle, WA

Sierra Club Legal Defense Fund
San Francisco, CA

Snake River Audubon Society
Iona, ID

Society for Range Management
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Stars Studs
Afton, WY

Stoddard Lumber Co.
St. Anthony, ID

Stone & Webster Engineering Corp.
Denver, CO

Sunrise Lions Club
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Sweetwater Co. Wildlife Assoc.
Rock Springs, CO

Targhee Wool Growers Assoc.
Teton City, ID

Teton Trail Rides
St. Anthony, ID

Teton Valley News
Driggs, ID

The Post Register
Idaho Falls, ID

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Union Oil Co. of California
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Wildlife Society
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Mack's Inn, ID

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Bozeman, MT

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Lake Forest, IL

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Ashton, ID

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Duane Handy
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Idaho Falls, ID

Orval Hanson
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Irvin F. Hanson & Sons
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St. Anthony, ID

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Charles N. Huseman, Sr.
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Verne Huser
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Vancouver, WA

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Gary Jeppson
Rexburg, ID

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Gene Jones
Mack's Inn, ID

Lecia Jones
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Esther Kafer
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Mike Keithley
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Dubois, ID

Phyllis Laird
Dubois, ID

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Stockton, CA

John La Shelle
Kansas City, MO

Monte Later
St. Anthony, ID

Dan Lechefsky
Denver, CO

Jim Lee
Island Park, ID

Rick Levinson
Laramie, WY

Harry Lewies
St. Anthony, ID

Gail Lewis
Idaho Falls, ID

Ernie Liable
Pocatello, ID

Michelle Liebel
Boise, ID

Mr. Bud Lilly
West Yellowstone, MT

John Lloyd
Billings, MT

Edward O. Logan, Jr.
Logan, UT

Lynn Looslie
Ashton, ID

J.A. Lydic
Salt Lake City, UT

Art Lynn
Vernal, UT

Leeanne G. MacColl
Portland, OR

Rodney W. Markley
Washington, D.C.

Vearold E. Martindale
St. Anthony, ID

Clyde Maycock
St. Anthony, ID

John Magleby
Rexburg, ID

Dick Manus
Idaho Falls, ID

Professor Ralph Maughan
Pocatello, ID

Amy Mazza-Scholl
Denver, CO

W.C. McComack
Phoenix, AZ

Skip McCrea
Rexburg, ID

Henry (Kenneth) McCullock
Thornton, ID

Peter B. McDougall
Pocatello, ID

J.H. McFadden
Idaho Falls, ID

Hugh C. McKay
St. Anthony, ID

Ben Meese
Ashton, ID

William R. Meiners
Boise, ID

Byron O. Meng
Idaho Falls, ID

Kathryn C. Merriam
Pocatello, ID

Clifton R. Merritt
Denver, CO

Emerson Miller
St. Anthony, ID

William G. Miller
St. Anthony, ID

Thomas A. Milne
Kansas City, KS

Dennis Moedl
Idaho Falls, ID

George W. Moffitt, Jr.
Bryn Mawr, PA

Mr. Wells Morris
West Yellowstone, MT

William B. Morse
Portland, OR

Tom Murdock
Mack's Inn, ID

Christian F. Murer
Denver, CO

Douglas M. Murphy
Ririe, ID

Ernie Naftzger
Pocatello, ID

Harold Nagle
St. Anthony, ID

Dick Nedrow
Ashton, ID

Thomas Neville
Bakersfield, CA

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Jalma Shaffer
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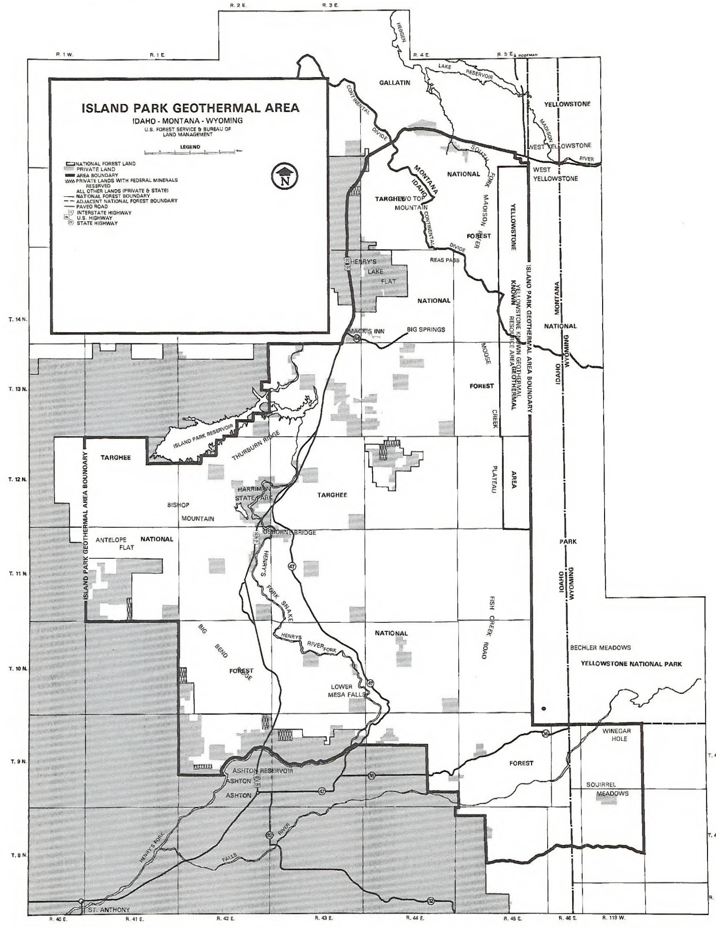


I. INTRODUCTION

This draft environmental statement considers the granting of leases for exploration and possible development of geothermal resources on Federal public lands, as authorized by the Geothermal Steam Act of 1970. These lands, collectively identified as the Island Park Geothermal Area (IPGA), are administered as follows:

- U.S. Department of Agriculture, Forest Service (Targhee and Gallatin National Forests) 477,346 acres
- U.S. Department of the Interior, Bureau of Land Management 10,685 acres
- Total—488,031 acres

Included within the acreage administered by the BLM are some private lands with mineral rights reserved to the Federal Government. More than seventy interested parties have filed approximately 200 lease applications for exploration and development of geothermal resources on these lands.

The Environmental Statement considers:

- Environmental, social and economic effects of the different phases of geothermal development
- Leasing alternatives
- Mitigation and monitoring
- Yellowstone National Park values

The Environmental Statement **does not** consider:

- Other energy resources in or near the IPGA
- Distribution of energy developed within the IPGA
- Economic feasibility of geothermal electrical power production
- Benefit-Cost analysis of geothermal development on a regional or statewide basis

Harmonizing geothermal development with environmental, social and economic values will be complex. The decision to prepare the environmental statement was based on:

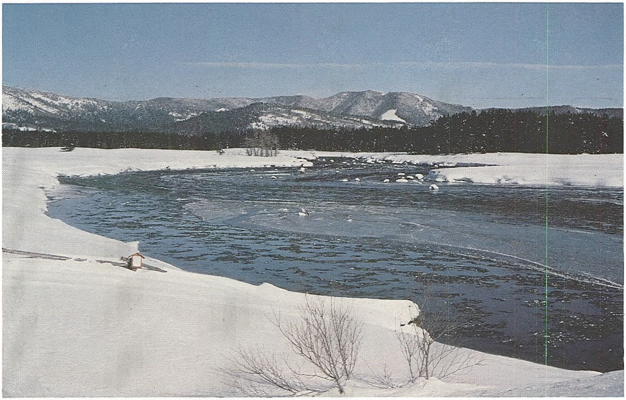
- Existing geothermal operations indicate that potential adverse impacts to ground and surface water, landscape, wildlife and recreational values could be significant.
- At least two endangered and one threatened species of wildlife inhabit the area. The Endangered Species Act of 1973 provides that Federal Agencies will take no actions which may be adverse to any endangered or threatened species.
- The proximity of Yellowstone National Park and its geothermal features must be considered.
- Disturbances from construction and long-term site occupancy could have significant effects on several wildlife species.
- The social structure and economies of several communities could be significantly affected.

The purpose of this draft environmental statement is to present a description of the existing or affected environment, show a range of alternatives for geothermal leasing, and consider the possible effects of implementing a leasing program. The alternatives were developed by an interdisciplinary team of resource specialists using existing and collected data and public involvement.

The draft environmental statement does not favor an alternative. After the public has reviewed this statement and commented, a final environmental statement will be prepared which will include a selected alternative. Figure 1 illustrates the environmental statement process.

Only information pertinent to geothermal resource leasing considerations is presented in this statement. The text (supported by an appendix) is brief to keep the effects of geothermal development clear to the reviewer. Considerable supporting data including source material, supporting calculations, and special reports are available for review at the Targhee National Forest Supervisor's Office in St. Anthony, Idaho.

The IPGA is located adjacent to Yellowstone National Park. The east boundary is 13.5 miles west of Old Faithful Geyser. The IPGA includes portions of Fremont County, Idaho; Gallatin County, Montana; and Teton County, Wyoming (Map 1).



The IPGA is astride the Continental Divide. West of the Divide are the headwaters of the Henrys Fork of the Snake River, a major tributary of the Columbia River, which flows into the Pacific Ocean. East of the Divide are the headwaters of the South Fork of the Madison River, a tributary of the Missouri River whose waters eventually reach the Gulf of Mexico.

ADMINISTRATION OF LEASING PROGRAM

The Geothermal Steam Act authorizes the Secretary of the Interior to issue leases to develop and use geothermal resources on Federal lands. This includes lands conveyed to other owners by the United States subject to a mineral resource reserve.

The Bureau of Land Management has jurisdiction over mineral and related subsurface resources on public lands. The Bureau role includes:

(1) Receiving and processing lease applications for non-competitive leases.

(2) Publishing lease sale notices for competitive bid lands.

(3) Awarding leases.

(4) Administering leases (except those functions assigned to the U.S. Geological Survey or Forest Service as outlined below).

The Conservation Division U.S. Geological Survey has expertise in geothermal geology and engineering, deep-well drilling and other technical aspects of geothermal development operations. Their role in the leasing program is:

(1) Supervising activity inside the area of operation on leased lands including enforcement of regulations covering all aspects of exploration, development and utilization.

(2) Preparing post-lease environmental studies on specific development proposals. The Forest Service or Bureau of Land Management provides input on surface management environmental considerations.

(3) Providing input on geothermal geology and geothermal operations for pre-lease environmental studies.

(4) Issuing Geothermal Resource Operational Orders.

(5) Concurring to special stipulations proposed (by the land managing agency) to mitigate or control situations peculiar to the lease area.

On National Forest land the Forest Service is responsible for:

(1) Preparing environmental assessments on suitability of National Forest lands for geothermal leasing purposes (Geological Survey provides input).

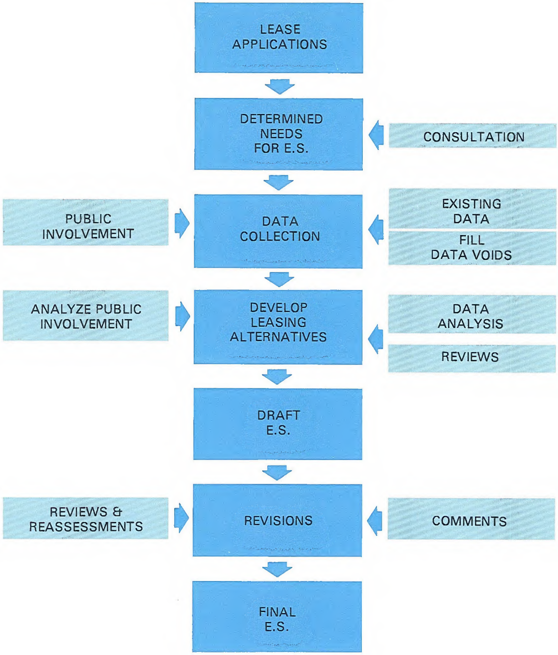
(2) Providing input to the Conservation Division, U.S. Geological Survey, on surface environmental considerations of post-lease environmental studies (Conservation Division has primary responsibility).

(3) Preparing lease stipulations covering special surface management problems.

(4) Issuing special use permits for occupancy of leased lands needed for development purposes.

(5) Supervising land uses on leased lands outside areas of operation.

FIGURE 1. ISLAND PARK GEOTHERMAL ENVIRONMENTAL STATEMENT PROCESS



GENERAL DEVELOPMENT PROCEDURE

Lands recommended for leasing will probably be developed in the following manner. Following lease issuance and prior to deep-well drilling (generally over 500 feet), the lessee must submit a plan for test drilling. The Conservation Division U.S. Geological Survey then prepares an environmental study. If the test drilling establishes an economically developable resource, the lessee submits a plan for development. The Conservation Division, with Forest Service input, prepares an environmental study of the proposed plan. The U.S. Fish and Wildlife Service reviews acreage to be leased and determines specific requirements necessary to protect fish and wildlife values. Special stipulations to protect values peculiar to the area are made a part of the plan. Since development of a geothermal field is usually accomplished in stages, the initial development plan is normally expanded and amended many times during the life of the project. All such plans must be approved by both the Conservation Division and the surface managing agency. If it is found during test drilling or subsequent development or production phases that environmental standards cannot be met, the law and regulations enable the Geological Survey to suspend operations pending solution of the problem(s).

THE NATURE OF A GEOTHERMAL RESOURCE

Geothermal energy is derived from the natural heat of the earth. Observations in mines and wells indicate that temperatures increase with depth to between 390° F and 1,830° F at the base of the earth's crust. In some places on the earth's surface, the natural heat flow is much greater than other places. Areas with abnormally high heat flow are potentially valuable for geothermal resource development and are frequently marked by hot springs.

Natural earth heat originates from radioactive decay, from friction between rock strata, and perhaps from the molten origin of the earth. Under present technology most of this heat is too diffuse to serve as a resource. Locally, however, it has been concentrated in the crust by volcanic activity, forces that create mountains and move continents, and by water circulating above buried molten rock. This heat is stored in rocks, water, and steam. Water and steam transfer the heat through pores, fractures, and fissures.

Four types of geothermal systems are known to occur in nature; geopressured, hot water, vapor dominated and hot, dry rock. The hot water type is most probable in the IPGA. Hot water systems are thought to be thermally driven; that is, groundwater from rain and snow is heated by a local heat source and moves upward (figure 2). This upwelling of hot water often reaches the surface as hot springs, geysers, and other surface phenomena. Temperatures of the water may range from about 195°F to more than 300°F.

A well drilled into such a resource can serve as an escape route for the hot water which is likely to be under high pressure. This water and steam are transported by pipeline to a power plant where electricity is generated, or to an area where the heat in the steam and/or water is used for non-electrical application (e.g. space heating, drying, etc.).

Once cooled, the geothermal fluid is either discharged to the surface or reinjected. The duration of a geothermal operation depends on the rate heat is removed from the producing zone. It also depends on how the water bearing and water transmitting characteristics of the rock in the heated zone change through time.

The hot water and vapor dominated systems produce the hydrothermal phenomena in Yellowstone National Park. At least one hot spring system in the Park is vapor dominated. This type is rare. In such a system, a great supply of heat exists but very little water enters the heated rock. Consequently, the fractures and pores in the rock hold steam.

PHASES OF GEOTHERMAL ENERGY DEVELOPMENT

Four phases of geothermal development are:

(1) Exploration

(2) Test Drilling

(3) Construction and Development

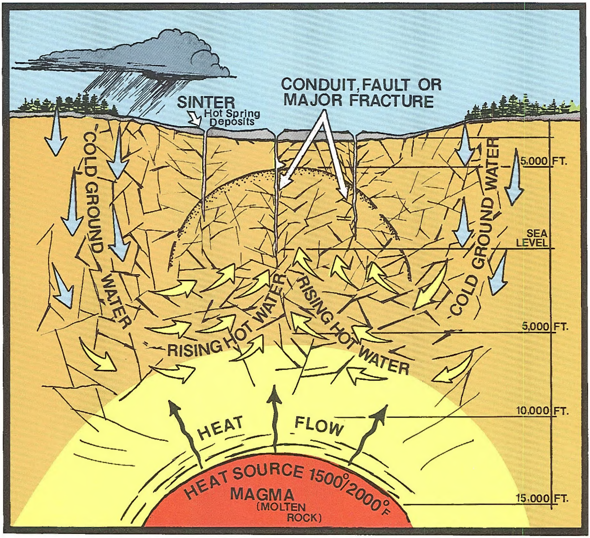
(4) Operation

Exploration

Exploration is done to locate and define the extent of geothermal reservoirs and determine the economical and financial feasibility of development. Exploratory operations may include aerial and surface surveys. Small fixed wing aircraft and helicopters make low level flights (one hundred to five hundred feet) for heat and magnetic sensing and initial reconnaisance of geological features. Flights above three thousand feet are made to conduct photograhic and magnetic sensing and geological visual reconnaisance surveys.

Surface exploration activities which use existing roads and trails are classified as either casual or intensive.

FIGURE 2. CROSS SECTION OF A GEOTHERMAL AREA



Source: Testimony for the Subcommittee on Water and Power Resources, Senate Committee on Interior and Insular Affairs, June 13, 1973.

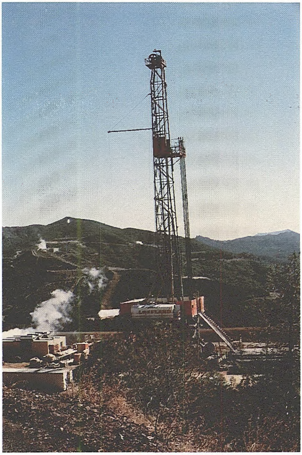
Casual exploration requires little land disturbance and may include geochemical surveys of water and vegetation, stratigraphic, lithological and structural geologic mapping, and micro-gas surveys where air samples are taken from various points. Other casual exploration activities include reconnaisance of surface features and natural phenomena without land disturbance, geophysical exploration including resistivity, microseismic, magnetic and gravity surveys and ground noise studies.

Intensive activities require minor land disturbances. This includes shallow well drilling for temperature gradient and heat flow measurement. Road construction and clearing are seldom required for access to these sites.

Test Drilling

Test wells are drilled to provide subsurface geologic data, locate productive zones, help delineate limits and provide a means for determining the physical and chemical properties of reservoir fluids. Locations for test **wells** are determined from data acquired during exploration.

Test drilling equipment often consists of a truck mounted drilling rig and truck mounted air compressor or water tank, depending on whether water or air is used in the drilling. In some cases a drill rig with a conventional superstructure is used. Drilling areas or pads generally require clearing or leveling of one half to two acres. Drilling rigs, mud pumps, mud tanks, generators, drill pipe stockpiles, toolsheds, etc., are usually on the drill pad. Storage tanks may be either on the pad or on another nearby site. A reserve pit (sump) six to



In the test drilling and construction and development phases, large drill rigs are used. These rigs usually drill to depths greater than 5,000 feet.

eight feet deep covering a surface area of approximately 1,000 to 10,000 square feet is often excavated to hold waste fluids produced during drilling operations.

The investment in each well is considerable. Recent wells (1977) cost an average of $100 per foot or $600,000 for a 6,000 foot well.

If promising wells are developed during the test drilling phase, production testing is conducted to clean them and to determine the flow rate, composition and temperature of fluids and gases, recharge characteristics, pressures, compressibility and other physical properties of reservoir fluids. Hydrodynamic properties and/or boundary characteristics are also determined during production testing. If a steam resource exists, venting of wells to the atmosphere is included in this process. Venting is done through a system of mufflers to prevent noise exceeding ambient levels at a distance of about one-half mile. Noises may be muffled even more effectively by venting under water. Production testing seldom extends beyond two or three days.

Construction and Development

Favorable results in test drilling and production testing programs generally lead to drilling of additional wells to develop a field. Field development requires improvement of access roads to standards suitable for full-time use. Living quarters, with the necessary water and sewage facilities, must be added during this phase, or must be available within commuting distance.

Development of a large geothermal field involves clearing and grading for access roads, well drilling pads, and pipelines. Well pads are from one-half to two acres. Between 5 and 25 wells are usually required to supply one power plant, depending on geothermal reservoir characteristics and individual wells. Pipeline clearings need only be wide enough to accommodate equipment needed for their construction and fire safety. It is not necessary to clear corridors wide enough to prevent trees from falling across the pipeline.

If the resource is developed for power, construction of facilities for generation and transmission of power follows an examination of the environmental effects including an analysis of available information on the geothermal reservoir and fluids. Power generation and transmission facilities are constructed in stages consistent with the capacity of the geothermal reservoir.

Above ground insulated pipes with U-shaped expansion loops are sometimes used to pipe steam or hot water from wells to power plants. Underground pipelines are possible but under present technology, because of pipe expansion and high costs, are impractical. Installation of underground pipes would increase pipeline costs by about 25%.

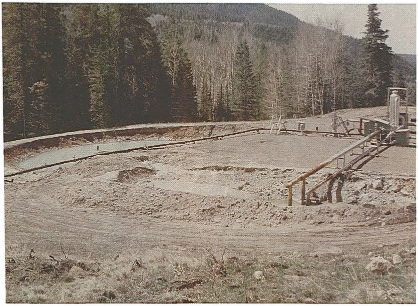
Operation

During the operation phase, maintenance of industrial plants, power plants, related facilities and the drilling, redrilling and workover of geothermal wells to maintain production takes place. Construction during the operation phase is reduced and allows much of the land in the leased area to be returned to other uses.

Throughout the life of the geothermal field, wells must be improved and maintained and new wells must be drilled to keep an adequate supply of steam or hot water flowing. Information is obtained on site and from regional geohydrology and hydrodynamics studies. This includes data such as rate and path of recharge and natural discharge of the geothermal reservoir. Prediction of the effects of scaling, extraction of geothermal fluids and estimates of reserves, optimum rates of production and resource conservation are also obtained.s

Site reclamation begins with the completion of the first well and continues throughout the life of the field. Wells, power plants, and other installations are removed as the geothermal resource is exhausted. Thus, in the same field reclamation may be under way in one part while development is in progress in another.

Complete reclamation includes removing all installations such as pipe, buildings, generators, and power transmission towers and lines. Wells are sealed; roads, well pads, and other clearings are regraded and revegetated.



KNOWN GEOTHERMAL RESOURCE AREA DEFINITION

A Known Geothermal Resource Area (KGRA) is a region in which the geology, nearby discoveries, competitive interests, or other indications would, in the opinion of the Secretary of the Interior, lead experts to believe the prospects for extracting geothermal steam or associated geothermal resources are good enough to warrant spending money for the purpose (Geothermal Steam Act of 1970). Lands administered by the U.S. Forest Service within the IPGA contain two KGRA's: the Yellowstone KGRA containing 42,400 acres and the Island Park KGRA with 28,350 acres. Geothermal leases for areas within a KGRA are issued on a competitive bid basis. Lands outside KGRA's are leased non-competitively.

USES OF GEOTHERMAL RESOURCES

Among the possible uses of geothermal resources are generation of electric power, space heating, industrial processing, and some applications in agriculture. Figure 3 shows possible uses and the approximate required temperature of geothermal fluids or steam for each use.

The life of geothermal fields fully developed for economical conditions is generally believed to be 25 to 100 years. The Larderello Field in Italy, which is not fully developed, has operated since 1913, a period of 65 years.

FIGURE 3. THE REQUIRED TEMPERATURE OF GEOTHERMAL FLUIDS (APPROXIMATE)

Temperature °F	°C	Use
392	200	
374	190	
356	180	Evaporation of Highly Conc. Solutions Refrigeration by Ammonia Absorption Digestion in Paper Pulp, Kraft
338	170	Heavy Water via Hydrog. Sulfide Proc. Drying of Diatomaceous Earth.
320	160	Drying of Fish Meal Drying of Timber
302	150	Alumina via Bayers Process
284	140	Drying Farm Products at High Rates. Canning of food.
266	130	Evaporation in Sugar Refining. Extraction of Salts by Evaporation and Crystalization.
248	120	Fresh Water by Distillation. Most Multiple Effect Evaporations, Concentr. of Saline Sol.
230	110	Refrigeration by Medium Temperatures. Drying and Curing of Light Aggreg. cement Slabs.
212	100	Drying of Organic Materials, Seaweed, Grass, Vegetables, etc. Washing and Drying of Wool.
194	90	Drying of Stock Fish. Intensive De-Icing Operations.
176	80	Space Heating. Greenhouses by Space Heating.
158	70	Refrigeration by Low Temperature.
140	60	Animal Husbandry. Greenhouses by Combined Space and Hotbed Heating.
122	50	Mushroom Growing. Balneological Baths.
104	40	Soil Warming.
86	30	Swimming Pools, Biodegradation, Fermentation. Warm water for year around Mining in Cold Climates. De-Icing.
68	20	Hatching of Fish, Fish Farming.

Temp. Range of Conventional Power Production (180 °C to 140 °C)

Source: **Geothermal Development**, final environmental statement for the Breitenbush Area of the Willamette and Mt. Hood National Forests, Oregon, Jan., 1978, p. 14.

II. AFFECTED ENVIRONMENT

PHYSIOGRAPHY

A major part of the IPGA is the Island Park caldera, a large volcanic feature located between the Eastern Snake River Plain and the Yellowstone volcanic plateau of Yellowstone National Park. Prominent topographic features include the western rim of the caldera, scattered volcanic buttes, and extensive volcanic flows that moved westward from Yellowstone National Park.

North and northeast of the caldera the Continental Divide separates Idaho and Montana and divides the headwaters of the Columbia and Missouri Rivers. Henrys Fork of the Snake River flows to the Columbia River which moves westward to the Pacific Ocean. The South Fork of the Madison River flows to the Missouri, a tributary of the Mississippi River, which empties into the Gulf of Mexico.

Elevations range from 8,386 feet on the Continental Divide to 5,160 feet near Ashton, Idaho. Extensive flat areas occur in Henrys Lake Flat, in the interior of the calder, and at Antelope Flat on the west side of the IPGA (Map 1).

LANDTYPES AND SOILS

Influences of geologic history and processes on the various rock and earth materials in the IPGA have produced a variety of landtypes (map 2). The prominent topographic features are the result of the volcanic and pre-volcanic mountain building aspects of the region's history. Scarps, canyons, and elevated plateaus border the highlands. Erosion in the uplands brings materials down to the broad open area at lower elevations, especially around Henrys Lake. Winds blow materials into the caldera bottom; no surface water network is found in this area. Map 2 shows the landtype associations in the IPGA and Table 1 displays the characteristics of each landtype and its soils.

Within the IPGA, soils have been derived from the products of weathering of rock and from materials brought by wind, water and glaciers.

Depth of soil depends on steepness of slopes and varies from 10 inches to tens of feet deep. In most locations, fractured bedrock lies beneath the soil at a depth of more than 40 inches.

Soil textures vary due to differences in parent materials and climate. Coarse-loamy, fine loamy, and loamy skeletal are prevalent. Except for deep accumulations of loess (wind blown) soils, most soils contain cobble and gravel sized materials. Generally the soils have good porosity and permeability.

Generally the soils have good porosity and permeability.

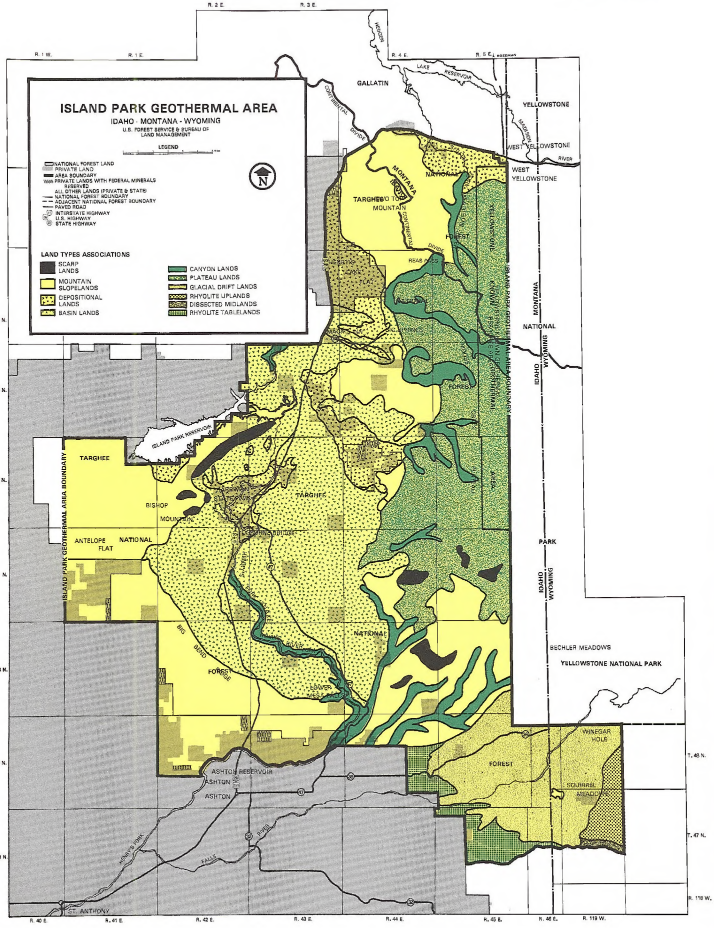

ISLAND PARK GEOTHERMAL AREA
IDAHO - MONTANA - WYOMING
U.S. FOREST SERVICE & BUREAU OF LAND MANAGEMENT
LEGEND
NATIONAL FOREST LAND
PRIVATE LAND
AREA BOUNDARY
PRIVATE LANDS WITH FEDERAL MINERALS RESERVED
ALL OTHER LANDS (PRIVATE & STATE)
NATIONAL FOREST BOUNDARY
ADJACENT NATIONAL FOREST BOUNDARY
PAVED ROAD
INTERSTATE HIGHWAY
U.S. HIGHWAY
STATE HIGHWAY
LAND TYPES ASSOCIATIONS
SCARP LANDS
MOUNTAIN SLOPELANDS
DEPOSITIONAL LANDS
BASIN LANDS
CANYON LANDS
PLATEAU LANDS
GLACIAL DRIFT LANDS
RHYOLITE UPLANDS
DISSECTED MIDLANDS
RHYOLITE TABLELANDS
GALLATIN
HEBGEN
LAKE
RESERVOIR
CONTINENTAL DIVIDE
YELLOWSTONE
WEST YELLOWSTONE
MADISON
RIVER
TARGHEE
NATIONAL
FOREST
REAS PASS
HENRYS LAKE FLAT
BIG SPRINGS
MONTANA
IDAHO
WYOMING
NATIONAL
PARK
ISLAND PARK RESERVOIR
ISLAND PARK GEOTHERMAL AREA BOUNDARY
BISHOP MOUNTAIN
ANTELOPE FLAT
HARRIMAN STATE PARK
OSBORNE BRIDGE
BIG BEND RIDGE
LOWER MESA FALLS
BECHLER MEADOWS
YELLOWSTONE NATIONAL PARK
WINEGAR HOLE
SQUIRREL MEADOWS
ASHTON RESERVOIR
ASHTON
HENRYS FORK
FALLS RIVER
ST. ANTHONY
R. 1 W.
R. 1 E.
R. 2 E.
R. 3 E.
R. 4 E.
R. 5 E.
R. 40 E.
R. 41 E.
R. 42 E.
R. 43 E.
R. 44 E.
R. 45 E.
R. 46 E.
R. 119 W.
R. 118 W.
T. 14 N.
T. 13 N.
T. 12 N.
T. 11 N.
T. 10 N.
T. 9 N.
T. 8 N.
T. 48 N.
T. 47 N.

TABLE 1. LANDTYPE ASSOCIATIONS AND SOIL CHARACTERISTICS

LANDTYPE ASSOCIATION	GEOLOGY (PARENT MATERIAL)	% SLOPE GRADE	ASPECT	VEGETATION	SOIL DRAINAGE	EROSION POTENTIAL	SLOPE FAILURE POTENTIAL	LIMITATIONS FOR USES
Depositional Lands	Glacial outwash, alluvium	0 to 10	South	Sage, grasses, some drought rasistent forbs	Well drained to excessively drained	Moderetely low	Low to moderately low	High potential for pollution of groundwater from septic systems
Besin Lands	Glacial outwash (around Henrys Lake) basalt (in the caldera)	0 to − 15	Nearly level to southerly	Lodgepole pine	Well drained to axcessivaly drained	Moderately low	Low	Much bedrock at or naar surface (in caldera)
Mountain Slope Lands	Basalt, rhyolite flows and welded tuffs, sedimentary units	0 to > 65	All	Lodgepole pine, aspen, Douglas fir, choke-cherry, service-berry, mountain ash, grasses and forbs	Well drained to excessively drained	Moderate	Moderately low to low	Slumping of soils due to increased pore water pressures (in sedimentary rocks); erosion on steep igneous slopes
Scarp Lands	Rhyolite flows	45 to 65	South to south-west.	Grasses, forbs, low shrubs to conifers end stunted aspen where soil and moisture support these	Well drained	Moderetely high	Moderetely low	Erosion of soils where water is concentrated
Plateau Lends	Rhyolite flows	25 to > 65	South to west	Subalpine fir, grouse whortle-berry, lodgepole pine	Well drained to excess-ively drained	Moderate	Moderetely low to low	Potential for pollution of distant or nearby springs; septic system
Canyon Lands	Volcanic rocks	25 to > 65	All	Lodgepole pine, grouse whortle-berry, pine grass	Excess-ively to well drained	Moderate	Moderately low	Steep slopes preclude various uses
Glacial Drift Lands	Glacial drift	5 to 30	All	Lodgepole pine, Douglas fir, aspen (below 7000 ft.) Engelmann spruce, white-bark pine, subalpine fir	Moderately to well drained	Low to moderately low	Low	Localized flooding and seasonal high water table
Rhyolite Uplands	Rhyolite flows and some glacial drift in drainage	10 to 45	All	Lodgepole pine, huckleberry and pina grass; Douglas fir and subalpine fir common on steeper slopes	Well drained	Moderate	Low	Soils erosive where unusual amounts of water are concentrated
Rhyolite Tablelands	Rhyolite with loess mantle; some glacial drift	3 to 30	West	Lodgepole pine, various ground cover	Modarately well to well drained	Modarate	Low	Ponding of water troublesome where road drainage is poor; slick when wet, ruts easily
Dissacted Midlands	Rhyolita, glacial drift and silty eolian deposits on north facing slopes	North aspects: >50% south aspects convex slopes, very steep to to gentle slopes	North and south for slopes; all for bottom-lands	Complex pattern tiad closely to slope aspect and landform: dansa conifar stands on north canyon slopes; brush and open timbar on south aspects; grass-forb-sub alpine fir parklands on faceted west aspects	Well drained to moderetely well	Moderate to low	Low in bottom-lands, high on slopes	Localized, seasonal flooding in bottomlands; slope stability problems

Source: Island Park Land Management Plan, July 1978; West Slope of the Tetons Land Use Plan, unpublished U.S. Forest Service documents

CLIMATE

The IPGA has a climate that is wet in spring, fall and winter; summers are cool and short, and winters bring snow, the major portion of the annual precipitation. Westerly prevailing winds are governed by the opposing Aleutian low and Pacific high pressure systems. In winter, moisture laden southwesterly winds move into the region due to the controlling influence of the Aleutian low. The mountains and other high elevations in the IPGA cause moisture in the air masses to fall as snow. As summer approaches, the Pacific high becomes the primary controller of the weather, reducing the intensity of the winter process. In summer, increased occurrence of convective cell storms sometimes generates high intensity, short duration storms. Occasionally during summer and winter, a reversal of normal air flow can occur because of continental high pressure systems. At these times, cold dry winter air, or hot, dry summer air moves westward.

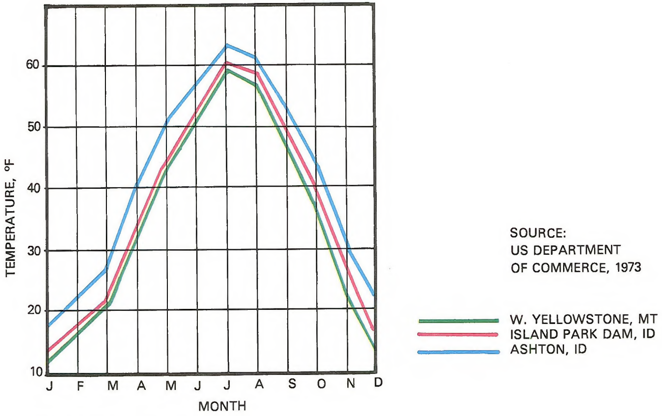
Various weather data are collected within the IPGA. Weather conditions studied include precipitation (snow depth, water content of snow, rain, and duration of rain), temperature, wind speed and direction, and relative humidity. Annual temperature and precipitation changes are shown in Figures 4 and 5; data collected at snow courses are shown in Table 2.

The freeze-free periods for Ashton and for Island Park Dam are 90 days (early June to early September) and 45 days (early July to mid August), respectively. At the higher elevations in the IPGA a frost can occur at any time.

The Forest Service measures wind speed and direction at the Buffalo Ranger Station from June to October. From July-September, 1974-1977, the prevailing winds came from the southwest. The second and third most common wind directions were south and southeast, respectively. Winds also have blown from the northwest, north, east and west. Since 1967, wind speeds from June to September have commonly been below 10 mph. The highest wind speed reported from 1967-1977, taken around 2:00 p.m., Mountain Time, was 29 mph. Winter wind speeds and directions have not been studied.

The topography of the region around the Idaho and Wyoming parts of the IPGA does not allow thermal inversions to form; inversions are common in the winter months in the W. Yellowstone vicinity.

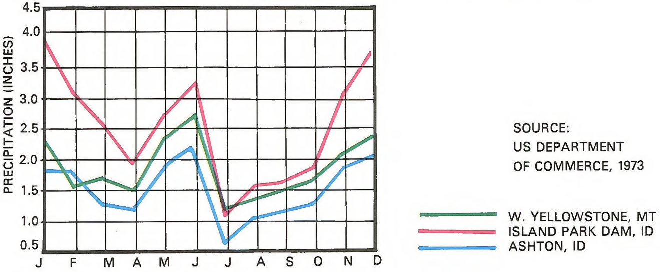
FIGURE 4. MEAN MONTHLY TEMPERATURES FOR ISLAND PARK GEOTHERMAL AREA, 1941-1970



MEAN ANNUAL TEMPERATURE (°F)

LOCATION	ELEVATION (FEET)	TEMPERATURE
W. YELLOWSTONE, MT	6662	34.9
ISLAND PARK, ID	6300	36.5
ASHTON, ID	5220	41.0

FIGURE 5. MEAN MONTHLY PRECIPITATION FOR ISLAND PARK GEOTHERMAL AREA 1941-1970



MEAN ANNUAL PRECIPITATION (INCHES)

LOCATION	ELEVATION (FEET)	AMOUNT
W. YELLOWSTONE, MT	6662	22.67
ISLAND PARK DAM, ID	6300	30.84
ASHTON, ID	5220	18.27

TABLE 2. SNOW COURSE DATA FROM THE ISLAND PARK GEOTHERMAL AREA (IPGA) (INCHES)

(sd = snow depth, we = water equivalent[1], por = period of record)

Snow Course		January 1			February 1			March 1			April 1			May 1			June 1		
		sd	we	por	sd	we	por	sd	we	por	sd	we	por	sd	we	por	sd	we	por
Black Bear, MT[2]	min:	20	3.7	'73 to '77	33	8.1	'73 to '77	38	9.9	'72 to '77	57	17.5	'72 to '77	17	7.7	'72 to '77	48	3.4	'72 to '77
elev. 7,950 ft.	max:	86	24.9		122	40.9		126	48.2		165	86.8		137	66.6		102	58.7	
Island Park, ID[3]	min:	11	1.0	'38 to '73	24	3.7	'38 to '73	30	7.6	'38 to '73	29	8.5	'38 to '73	9	2.9	'43, & '49 '63 to '73			
elev. 6,315 ft.	max:	58	11.6		73	19.7		75	28.4		83	30.7		47	18.4				
Latham Spring, ID[4]	min:	25	8.3	'63 to '64	83	18.6	'82 '64 '66 to '73	55	15.6	'61 '63 to '73	59	20.6	'61 to '73	82	34.2	'67 '72 to '73			
elev. 7,650 ft.	max:	42	8.4		104	34.4		107	41.4		116	46.6		107	44.2				

[1] Water content varies with the density of the snow

[2] Near Continental Divide and border of Yellowstone National Park

[3] Near mouth of the Buffalo River; see map 5

[4] Slightly northeast of Buffalo Ranger Station and roughly 2½ miles west of Yellowstone Park border; see map 5

Source: Soil Conservation Service, U.S. Department of Agriculture

AIR QUALITY

The sparsely populated and non-industrialized IPGA has high air quality. Sources of air pollutants include:

Natural Pollutants

—Forest fires
—Pollen
—Wind blown dust

Man Caused Air Pollution

—Forest fires
—Wood burning stoves
—Auto emissions
—Burning of forest debris (slash)
—Road dust
—Dust from farming operations outside the IPGA

No natural venting of gases, often associated with hydrothermal phenomena, is known to occur anywhere in the IPGA. Human activities that cause air pollution do not occur simultaneously or continuously. Auto emissions are greatest when traffic from tourists and recreationists peaks in the summer; slash burning occurs in the fall, and wood is burned in fall, winter and spring for domestic heating. Because of this, pollutants vary in chemical and physical nature during the year.

Air quality in the IPGA was sampled in October 1977 and in late June and early July, 1978. The sampling and some of the analyses was done by the Conservation Division of the US Geological Survey. The results are:

	1977 (Oct. 7-12; 4 stations)	1978 (June 30, July 1-5; 6 stations)
H_2S	Not detected	Not detected
SO_2	Not detected	25 to 26.4 ug/m³
NO_x	Not detected	below detection limit to 108 ug/m³
NH_3	Not detected to 0.028 ppm	7.9 to 135 ug/m³
suspended particulates	4.74 to 63.0 ug/m³	21.7 to 685 ug/m³

Road dust accounts for the greatest percentage of the total suspended particulates (83 to 96%), followed by pollen (4 to 15%), and soot (0 to 7%).

Idaho and Federal air quality standards were not exceeded anywhere in the 1977 survey, although the same standards were exceeded in 1978 for particulates at a few stations affected by road dust.

The US Environmental Protection Agency has placed the IPGA and adjoining areas into the following clean air classes:

Area	Class	General Constraints
Yellowstone National Park	I	Only minor air quality deterioration tolerated*
Upper Snake River Valley and IPGA	II	Moderate air quality deterioration tolerated

*Air quality in certain locations may be below Class I standards. For example, excessive H_2S and possibly SO_2 may be evident in the air near Mammoth and other geyser basins.

GEOLOGY

The geologic history of the IPGA is dominated by widespread volcanic activity, although sedimentary and metamorphic rocks are also found. Water, gravity, wind, and glaciers have acted on the geologic units and on the products of rock disintegration. While water and gravity reworked and redistributed materials already in the IPGA, wind and glaciers brought foreign earth materials into the IPGA.

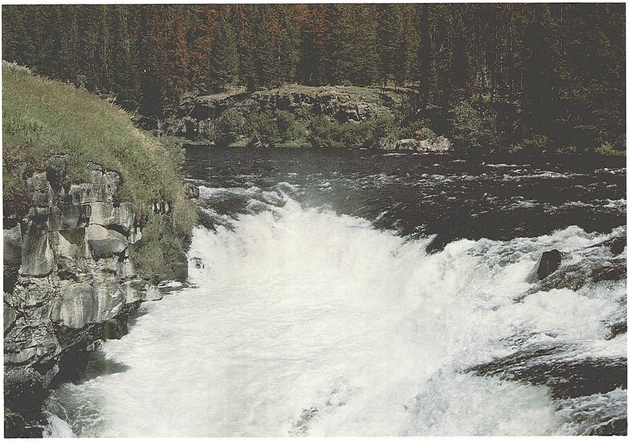
Geologic History

According to a geologic history summarized by Whitehead (1978), the upper Henrys Fork basin is at the eastern end of the Snake River Plain, a downwarped feature extending in an arc across southern Idaho and into Wyoming. The plain cuts across preexisting Mesozoic and Cenozoic structures at nearly right angles. The pre-Cenozoic rocks underlying and bordering the plain are comprised of igneous, metamorphic, and sedimentary rocks. As the plain was being downwarped, volcanism and sedimentation filled it with basalt,

rhyolite, and sedimentary deposits.

A large shield volcano formed in the south central part of the IPGA and later collapsed to form the Island Park caldera. The elliptical collapse structure covers an area approximately 18 by 23 miles. The western and southern rims of this feature are clearly visible as a semicircular arc formed by Thurmon Ridge and Big Bend Ridge (Map 1).

Rhyolitic ash flows originating from the Yellowstone Plateau covered the eastern part of the IPGA before and after eruption of rhyolitic and basaltic flows from the pre-caldera shield volcano. The flows that occurred after the caldera formed covered the eastern rim and overlapped flows from the collapsed volcano. At about the same time, basalt flows occurred southeast of the caldera along the southern part of the study area.



Glaciers scoured the highlands in late Pleistocene time, providing outwash to the valleys and stream channels. Contemporaneously, basalt of the Snake River Group flowed from vents south and west of the caldera and covered some of the rhyolitic ash flows. Some basalt lapped up onto the caldera rim and may have spilled into the caldera itself. Additional rhyolitic lava and ash flows were coeval with the glacial deposits and basalt flows of the Snake River Group. These latest flows issued from vents north and east of the caldera and covered much of the eastern part of the study area.

Rock Types and Geologic Structures

Descriptions of the major rock types are found in Table 3. The general geology of the area is shown on Map 3. The geologic reports used in its compilation provide much more detail than the units shown on the map.

3. GENERAL GEOLOGY

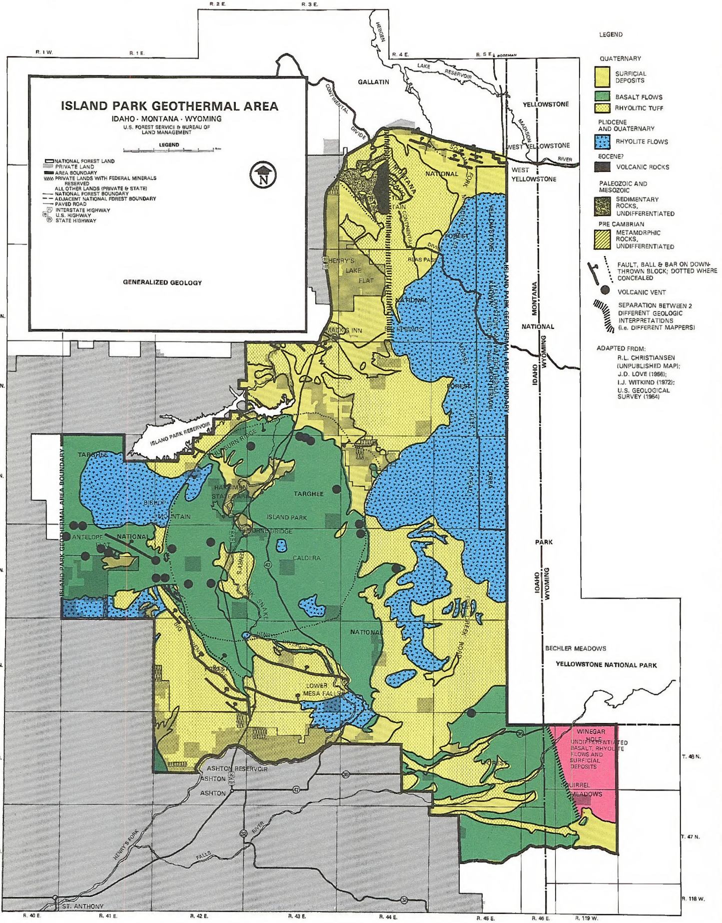


TABLE 3. ROCK UNITS IN THE ISLAND PARK GEOTHERMAL AREA

ERA	PERIOD	EPOCH	ROCK UNIT	DESCRIPTION
Cenozoic	Quaternary	Holocene	Alluvium	Alluvium, colluvium, landslide and glacial materials; primarily unconsolidated silt, sand and gravel.
		Holocene and Pleistocene	Plateau Rhyolite	Rhyolitic ash-flow tuff, light gray, dense, lithoidal, fine grained to aphanitic; angular to round phenocrysts of quartz, sanidine, clinopyroxene, orthopyroxene, fayalite, and sphene make up about 25% of rock volume.
			Basalt	Composed of basalt of the Snake River Group, older basalt of Island Park caldera fill, and basalt south and southeast of Henrys Fork near Ashton. The flows consist chiefly of olivine basalt. Generally, the flows of the older basalt are of the pahoehoe type, whereas those of the Snake River Group consist of both aa and pahoehoe types.
			Yellowstone Group	Rhyolitic ash-flow tuff; consists of three formations similar in mineral content and chemical composition. Phenocrysts of quartz, sanidine, and oligoclase are common, some phenocrysts of clinopyroxene, fayalite, hornblende, chevkinite, allanite(?), apatite, and zircon. The formations are Lava Creek Tuff, Mesa Falls Tuff, and Huckleberry Ridge Tuff.
	Tertiary	Pliocene	Snake River Butte Rhyolite	Crystalline rhyolite, locally preserved glassy outer zone, somewhat hydrothermally altered; quartz, sanadine, plagioclase, and clinopyroxene present.
Cenozoic and Pre-Cenozoic	Pre-Quaternary	Pre-Pleistocene	Undifferentiated Rocks	Undifferentiated igneous, sedimentary, and metomorphic rocks. Includes igneous volcanic rocks of Tertiary age comprising about two 15-square mile areas, one roughly centered on Sawtell Peak, and the other from Mount Two Top south toward Reas Pass. Sedimentary and metamorphic rocks of pre-Tertiary age are exposed along the Continental Divide. The sedimentary and metamorphic rocks consist chiefly of limestone, dolomite, sandstone, siltstone, and quartzose sandstone.

Source: Whitehead, R.L., 1978; Pacific Northwest River Basins Commission, 1970; Christiansen, R., personal communication, 1978.

The subsurface distribution of geologic units is defined in a general way and only for parts of the IPGA because data are lacking. The thickness of the alluvium is better defined than that of other geologic units because drillers' logs are the chief source of subsurface information and most wells were drilled near stream channels in alluvial deposits.

A gravity survey by Peterson and Witkind (1975) indicates that the alluvial fill in the elongate valley of Henrys Lake is 3,600 feet or more thick. The fill is derived from volcanic and sedimentary rocks from adjacent highlands (map 3). It is thickest near the southern end of Henrys Lake and thins toward the edges of the valley. In the southern end of the valley near Big Springs, the alluvium is less than 100 feet thick, and at many places, only a few feet thick.

The eastern part of the basin and the Island Park caldera, which are partly covered by Plateau Rhyolite, were described in detail by Hamilton (1960 and 1965). In the Last Chance-Osborne Bridge area, the alluvial deposits are generally less than 100 feet thick and thin rapidly toward the south.

Normal faults found in the IPGA are shown on Map 3. The faults associated with the land collapse that created the caldera are superimposed on fault blocks which trend north to northwest. These blocks are bounded by normal and vertical faults. The Island Park area is flanked on the north and east by the very active intermountain seismic belt; however, Island Park itself is conspicuous by its lack of seismicity.

Economic Geology

The IPGA is not known for its mineral wealth or mineral production. Mineral commodities are limited to materials that are low in unit value. The absence of valuable ore deposits is a result of the recent volcanic activity.

Crushed rhyolite and basalt are used as road metal and aggregate; rhyolitic cinders are also used but are inferior to non-cinder basalt. Basalt is also used for building purposes (the facing of homes, chimneys, patio walks).

A deposit of pumicite is located in the Montana part of the IPGA. This light colored, finely divided volcanic ash or dust is most commonly added as an abrasive to hand soaps and household cleansers. Pumicite, in the past, was extracted from the Montana site and sold in small amounts as a polishing agent. The site is now inactive.

Some sand and gravel deposits are located on the Idaho and Wyoming parts of the IPGA, while the Montana section has limited quantities. These glacial and alluvial materials are used as aggregate for concrete and for subbase in road construction.

Variscite, a semiprecious mineral, occurs in sedimentary rocks near Mount Two Top at the north end of the Idaho part of the IPGA (see Map 1). This mineral slightly resembles turquoise and can be used in jewelry.

The IPGA is near the Willard overthrust belt, a geologic province with great oil and gas potential. Discoveries have been made in the overthrust belt in northern Utah and southwestern Wyoming. Oil and gas may be in Idaho as well, but the potential in and near the IPGA is unknown since no drilling has been undertaken.

The geothermal potential of the IPGA is unknown at present. Existing data are inadequate to predict areas of high geothermal potential. A hot geothermal system similar to that in Yellowstone National Park is not likely because no major silicic body now underlies the IPGA, as is the case for Yellowstone National Park. It is important to consider, however, that a lower temperature geothermal resource might exist at moderate depth. Thus, the exact nature of a geothermal system, if present, will probably not be known until a geothermal exploration and drilling program has been completed.

GEOLOGIC HAZARDS

Avalanches, Land and Earthslides

The potential for landslides, earthquakes and snow avalanches exists in the rugged mountains around Henrys Lake. The variety of sedimentary rocks, faults, the relative positions of rock units, and the erosion patterns could trigger some form of rock or earth failure. Abundant moisture from spring snowmelt can lessen stresses between soil and rock and between rock types resulting in an earth or rockslide. A major earthquake could have disastrous effects on loose and unstable slopes in these mountains. Map 4 indicates the area with the highest potential for these hazards. Elsewhere in the IPGA the possibility of these hazards is low to nonexistent.

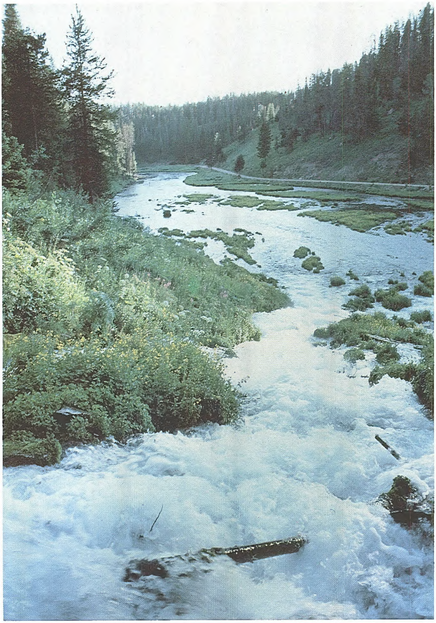
TABLE 4. HYDROLOGIC ASPECTS OF ROCK UNITS IN THE ISLAND PARK GEOTHERMAL AREA

(TDS = total dissolved solids; T = transmissibility)

Rock Unit[1]	Water-bearing Characteristics	Water Quality
Alluvium	Typical reliable source of water for domestic use; T ranges from 5,000 to 170,000 gal/day/ft	TDS rarely exceeds 1,000 and usually less than 500 mg/l; water generally moderately hard to very hard
Plateau Rhyolite	Extensive fractures create high secondary permeability; no well developed surface water drainage system; melt water and rain easily seep downward into soil and rock in the permeable ash flows; T ranges from 3,000 to 90,000 gal/day/ft	TDS generally less than 300 mg/l; water soft to moderately hard; Na and K predominate over Ca and Mg
Basalt	Yields abundant water for most uses. An important aquifer in parts of the IPGA Low rock permeability, high formation permeability; water travels between flows and along rubble separating flows; T ranges from 1,500 to 65,000 gal/day/ft	TDS generally less than 300 mg/l; Ca and Mg predominate over K and Na
Yellowstone Group	Generally yields adequate supplies of water for domestic and stock use. Highly permeable at places but in other places the unit is tightly welded and will not yield adequate supplies of water for irrigation use. Important to the basin's water yielding capability; T ranges from 400 to 12,000 gal/day/ft	Similar to Plateau Rhyolite
Snake River Butte Rhyolite	Intensely fractured and jointed, probable moderate to high permeability; no wells drilled	Probably similar to Plateau Rhyolite
Undifferentiated Rocks	Probable water bearing units are limestone, dolomite and sandstone; others are very poor suppliers of water or are aquicludes	Variable, depends on rock type; quartzose sandstone and some metamorphic and igneous rocks would probably be soft to moderately hard, while limestone and dolomite would be hard to very hard.

[1] The order of this column is the same as in table 3.

Source: Whitehead, R.L., 1978; Pacific Northwest River Basins Commission, 1970; Christiansen, R., personal communication, 1978



Warm River Spring flows 90,000 gallons of water per minute from the base of the Moose Creek Plateau.

Numerous springs occur within the IPGA; some are perennial and others are ephemeral (flowing only when the local groundwater supply is sufficient). The two largest, Big Springs and Warm River Spring, each discharge about 90,000 gal./min. to Henrys Fork and Warm River, respectively. Several springs are thermal (greater than 12° C or 54° F; map 5). Discharge values and chemical parameters from selected springs are shown in table 5. A more complete listing of chemical analyses of thermal and cold groundwater is in Appendix A and B.

There are 13 thermal features in Yellowstone National Park less than 12 miles from the IPGA. These include small seeps, springs, fumaroles, mud pots, thermally and chemically altered areas, and one small geyser. Temperatures range from 18° C (64° F) to 94° C (201° F) and flows range from relatively insignificant seepage to large volumes of warm water.

Data are not available in detail to determine groundwater flow patterns over the entire IPGA. However, some information for Henrys Fork basin indicates that groundwater movement occurs locally within the basin between low subbasin drainages. But in general, around Henrys Lake it moves toward the lake. South of Henrys Lake, it moves south, paralleling the flow of Henrys Fork. Near Island Park Reservoir, it moves south and east towards the reservoir. Near Ashton, it flows north and west toward Henrys Fork. However, most of the water in the Henrys Fork drainage basin above Ashton is from precipitation in the basin. A small part of

the basin's natural drainage system is in Yellowstone National Park on the Yellowstone Plateau where a large part of the basin's precipitation occurs. Groundwater flow in the West Yellowstone area is assumed to be from the highlands toward the South Fork of the Madison River. Groundwater flow in the Wyoming part of the IPGA is assumed to be towards the major streams draining the area.

TABLE 5. CHARACTERISTICS OF SELECTED SPRINGS IN THE ISLAND PARK GEOTHERMAL AREA

Name	Flow gal/min	Water Temperature °C and date of Measurement	Geohydrologic unit	Specific Conductance in field umhos/cm at 25° C	pH	Total Hardness mg/l
(Idaho)						
Big Springs	92,200	11.8 (9/8/77)	Rhyolitic flows & tuffs	110	6.7	21
Warm River Spring	90,000	10.3 (9/21/77)	same	118	6.8	21
Pineview Campground Springs	4,300	5.0 (9/10/75)	Basalt	82	—	—
Osborne Springs	3,460	5.5 (6/08/74)	Basalt	81	7.3	—
(Montana)						
Black Sand Spring	—	9.5 (9/07/77)	Alluvial obsidian sand; rhyolitic tuff	98	6.8	18
S. Fork Madison River Springs	—	4.8 (9/07/77)	Rhyolitic flows & tuffs	48	6.6	17

Source: Whitehead, R.L., 1978; U.S. Forest Service, 1977, unpublished records

The quality of IPGA groundwater is generally satisfactory for most uses and meets Federal and State drinking water standards. However, fluoride concentrations in some parts of the IPGA may exceed the recommended limit of 2.4 mg/l.

Groundwater in sedimentary rocks in the northern part of the IPGA is the calcium magnesium bicarbonate type; in basalts, it contains calcium and magnesium and relatively little sodium and potassium, and is less mineralized than water moving through the sedimentary rocks. In the rhyolitic flows and tuffs, it has a predominance of sodium and potassium over calcium and magnesium, and has a low dissolved mineral content. Table 4 summarizes the water quality characteristics of the IPGA rock types.

Human influences on the surface water and shallow groundwater systems are likely in areas of the IPGA where septic tank systems are used for waste disposal, particularly along streams where summer homes are concentrated.

Little is known about a geothermal resource in the IPGA. Most of the information on thermal water in the area is from a few water samples from selected springs, shown in Appendix A. However, detailed water quality data from Yellowstone National Park thermal water are available. The hot springs in the Shoshone and Upper Geyser Basins are known to be generally neutral to alkaline and have high concentrations of silica, sodium, chloride, bicarbonate, fluoride and boron. Some Upper Geyser Basin springs have acidic sulfate water (pH=2) and low chloride concentrations. Chemical analyses from hot springs and geysers on the west side of Yellowstone National Park appear in Appendix C.

Surface Water

The IPGA is an important headwaters area for the Snake River and Missouri River. Water from the Montana part of the IPGA drains into the Missouri River and water from Idaho and Wyoming drains into the Snake River. Three significant watersheds in the IPGA include the South Fork of the Madison River in Montana, Henrys Fork of the Snake River, primarily Idaho, and Falls River in Wyoming and Idaho (Map 5).

Henrys Fork of the Snake River winds through the center of the Island Park Geothermal Area.

Falls River originates in Yellowstone National Park and flows to Henrys Fork of the Snake River.

Data collection in the Upper Henrys Fork drainage began in 1890 when the US Geological Survey installed a gaging station on Henrys Fork near Ashton. Other stations were subsequently added and volumes of stored water in Henrys Lake and in Island Park Reservoir were also measured. Numerous miscellaneous streamflow measurements in the Upper Henrys Fork drainage have been made. A great deal of hydrological information is available for the Idaho part of the IPGA and some exists for the Montana and Wyoming parts.

The flow in Warm River, Buffalo River, and Big Springs Creek is maintained at a nearly constant rate by large contributions from groundwater. Minor streams are ephemeral, flowing only when the water table is high or when runoff is suitable. The mean annual discharge for two of the three main rivers draining the area is as follows: Henrys Fork near Ashton, 1,441 cfs (1,044,000 ac-ft./yr.; from 55 years of record), and Falls River, near the point where it leaves the IPGA, 777 cfs (562,900 ac-ft./yr.; from 61 years of record). Annual discharge data for the South Fork of the Madison River are not adequate to determine annual flow (table 6). Mean annual and mean monthly hydrographs for Henrys Fork and selected tributaries are presented in figure 6.

The flow on Henrys Fork is regulated at three dams located at Henrys Lake, Island Park Reservoir, and Ashton Reservoir. These dams prevent natural variation in flows. Water diversions into irrigation canals near the west edge of the IPGA alter the flow of Falls River during late spring and summer. No major diversions are made from the South Fork of the Madison River in Montana.

Island Park Reservoir stores water from Henrys Fork of the Snake River for downstream water uses.

Storage capacity for Island Park Reservoir, Ashton Reservoir, Henrys Lake, and Hebgen Lake are in table 7.

Major flooding is not a problem along Henrys Fork at most places because reservoirs control flows and the channel is well defined. Streams where localized flooding occurs from spring runoff are shown in map 4. High water invades low-lying willow thickets and does little damage. However, one exceptional flood on Thirsty Creek (map 5) in 1960 damaged U.S. Forest Service roads and undermined a quarter mile stretch of Union Pacific Railroad track.

5. WATERSHEDS

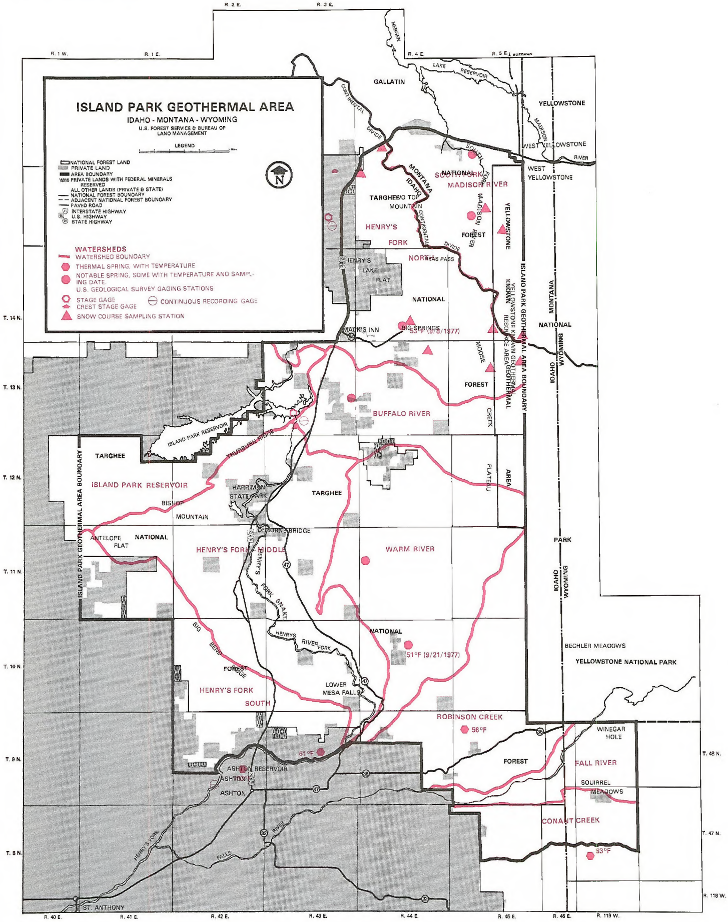


TABLE 6. DISCHARGE DATA FOR STREAMS IN THE ISLAND PARK GEOTHERMAL AREA

—IDAHO STREAMS—

Stream	Average Discharge, cfs	Period of Record	Recorded Peak Flows: cfs and date	Drainage Area in Square Miels
Henrys Lake Outlet, below dam	52.9 (38,330 ac-ft/yr)	46 yrs.	907 (6/1926)	99.3
Henrys Fork near Island Park, below Island Park Reservoir Dam	594 (430,400 ac-ft/yr)	42 yrs.	2,770 (4/1946)	481
Henrys Fork near Ashton, downstream of Ashton Reservoir Dam	1,441 (1,044,000 ac-ft./yr)	55 yrs.	6,220 (5/1925)	1,040
Falls River, 3 miles west of IPGA boundary	777 (562,900 ac-ft/yr)	61 yrs.	6,440 (6/1927)	326
Buffalo River, at Island Park	180 (130,090 ac-ft/yr)	9 yrs.	638 (4/30/38)	59.1
Warm River, at Warm River	210 (151,770 ac-ft/yr)	22 yrs.	900 (6/2/12)	145
Robinson Creek, at Warm River	120 (86,720 ac-ft/yr)	20 yrs.	1,140 (5/28/12)	126

—MONTANA—

Discharge in the S. Fork of the Madison River; measured at the US 191-20 highway bridge (the north edge of the IPGA)

Date	Flow, cfs
22 June 1977	110.1
10 August 1977	105
13 Sept. 1977	105

Source: US Geological Survey, 1976; US Geological Survey, personal communication, 1978; unpublished records of the US Forest Service

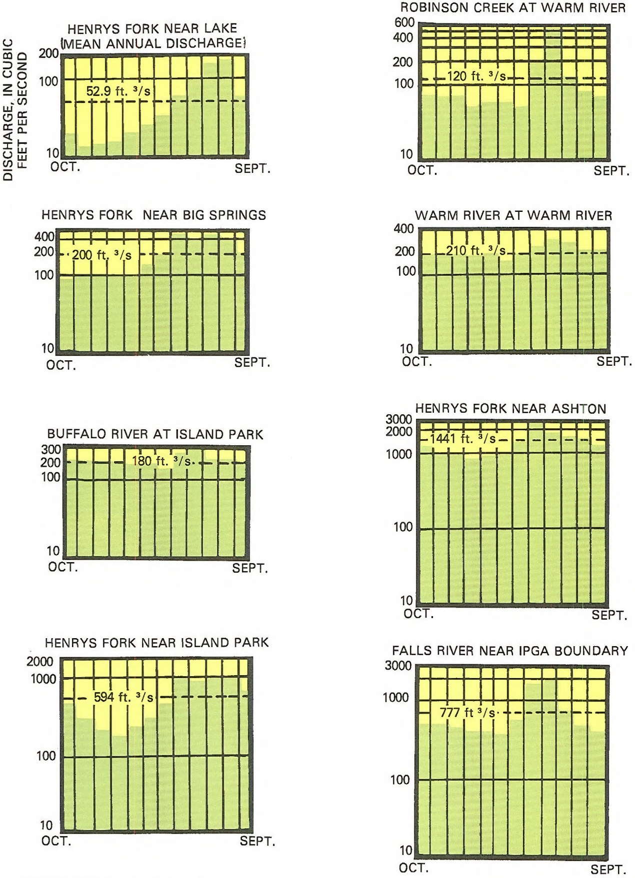
TABLE 7. STORAGE CAPACITY IN LAKES AND RESERVOIRS IN OR NEAR THE ISLAND PARK GEOTHERMAL AREA

Idaho	Capacity (acre-feet)	Drainage Area (square miles)
Henrys Lake	140—92,100	99
Island Park Reservoir	5,280—143,500	481
Ashton Reservoir	7,457[1]	1,040
Montana		
Hebgen Lake	200,000—350,000	905

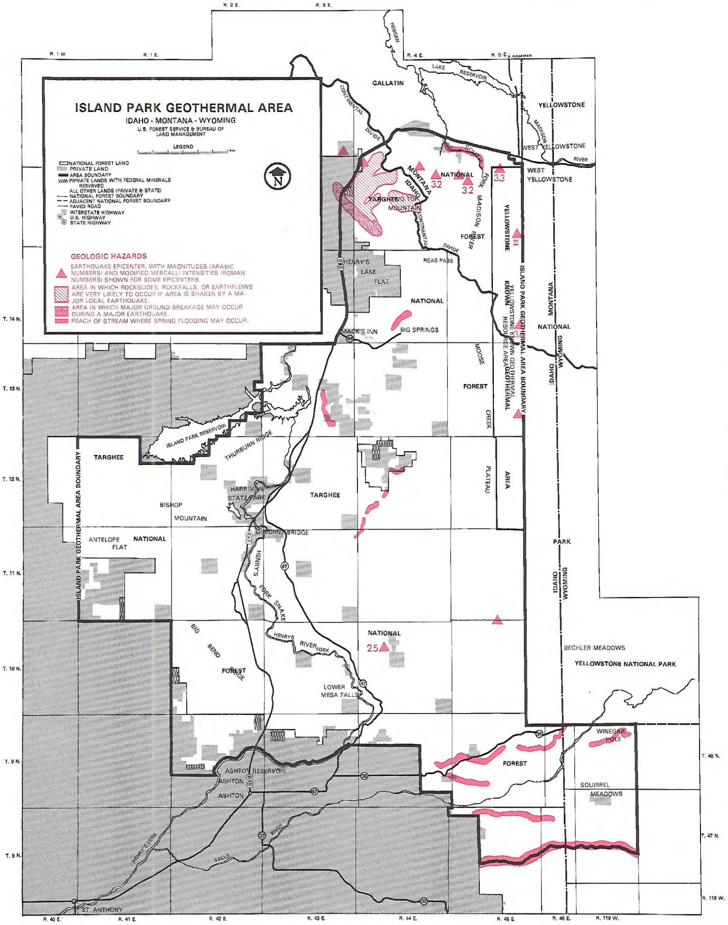
[1] Maintained near this volume for power generation

Source: US Geological Survey, 1976; personal communication with US Bureau of Reclamation, and Montana Power Company

FIGURE 6. STREAMFLOW CHARACTERISTICS IN THE IDAHO PART OF THE ISLAND PARK GEOTHERMAL AREA (IPGA)
(MEAN ANNUAL AND MEAN MONTHLY DISCHARGE)



SOURCE: Whitehead, R.L., 1978


ISLAND PARK GEOTHERMAL AREA
IDAHO - MONTANA - WYOMING
U.S. FOREST SERVICE & BUREAU OF LAND MANAGEMENT
LEGEND
NATIONAL FOREST LAND
PRIVATE LAND
AREA BOUNDARY
PRIVATE LANDS WITH FEDERAL MINERALS RESERVED
ALL OTHER LANDS (PRIVATE & STATE)
NATIONAL FOREST BOUNDARY
ADJACENT NATIONAL FOREST BOUNDARY
PAVED ROAD
INTERSTATE HIGHWAY
U.S. HIGHWAY
STATE HIGHWAY
GEOLOGIC HAZARDS
EARTHQUAKE EPICENTER, WITH MAGNITUDES (ARABIC NUMBERS) AND MODIFIED MERCALLI INTENSITIES (ROMAN NUMBERS) SHOWN FOR SOME EPICENTERS.
AREA IN WHICH ROCKSLIDES, ROCKFALLS, OR EARTHFLOWS ARE VERY LIKELY TO OCCUR IF AREA IS SHAKEN BY A MAJOR LOCAL EARTHQUAKE.
AREA IN WHICH MAJOR GROUND BREAKAGE MAY OCCUR DURING A MAJOR EARTHQUAKE.
REACH OF STREAM WHERE SPRING FLOODING MAY OCCUR.
GALLATIN
HEBGEN LAKE RESERVOIR
YELLOWSTONE
WEST YELLOWSTONE
MADISON RIVER
SOUTH FORK MADISON RIVER
CONTINENTAL DIVIDE
MONTANA
IDAHO
TARGHEE
TARGHEE PASS
TO TOP MOUNTAIN
NATIONAL
FOREST
3.2
3.2
3.3
III
REAS PASS
HENRY'S LAKE FLAT
MACK'S INN
BIG SPRINGS
ISLAND PARK GEOTHERMAL AREA BOUNDARY
YELLOWSTONE KNOWN GEOTHERMAL RESOURCE AREA
MOOSE CREEK PLATEAU
ISLAND PARK RESERVOIR
THURBURN RIDGE
HARRIMAN STATE PARK
BISHOP MOUNTAIN
ANTELOPE FLAT
OSBORNE BRIDGE
HENRY'S FORK SNAKE RIVER
BIG BEND RIDGE
2.5
LOWER MESA FALLS
ASHTON RESERVOIR
ASHTON
FALLS RIVER
ST. ANTHONY
BECHLER MEADOWS
YELLOWSTONE NATIONAL PARK
WINEGAR HOLE
SQUIRREL MEADOWS
WYOMING
PARK

Subsidence

Following the collapse of the land surface associated with the creation of the caldera, there has been no recognized land subsidence in the IPGA in historical times. The rock types at depth provide adequate support and are physically incapable of causing ground subsidence due to extraction of fluids held at depth. Some compaction of very thick unconsolidated materials (sand, silt) may occur where fluid is withdrawn.

Floods

Serious flooding is rare in the IPGA, though overbank flows occur in some streams during spring runoff. These areas of high localized flows along lesser IPGA streams are shown in Map 4.

Seismicity

In most of the IPGA, earthquake caused devastation has not occurred. However, on August 17, 1959, an earthquake of magnitude 7.1 (Richter Scale) violently shook the area around Hebgen Lake, Montana, near W. Yellowstone, Montana. The shocks affected 600,000 square miles, including all of the IPGA. Extensive damage was reported from W. Yellowstone, where foundations, chimneys, structures, railroad tracks, and roads were damaged. In the Idaho part of the IPGA, damage was also widespread but milder than in West Yellowstone.

Information from seismometers has been used to locate epicenters and compute magnitudes of earthquakes believed to have originated under the IPGA (Map 4). Hebgen Lake, W. Yellowstone, and an area around the nuclear reactor testing facility near Arco, Idaho are monitored with seismometers. A recent seismic risk map included the IPGA in a zone where major damage can occur. This zone has the highest risk and high intensity disturbances can be expected.

A study of Henrys Lake examined ground breakage, rockfall and rockslide hazards that could be associated with earthquakes of varying magnitudes. An earthquake could cause a sloshing effect in Henrys Lake which could flood parts of the shoreline and inundate low-lying land.

WATER RESOURCES

Several studies of ground and surface water in the IPGA have been done. A recent investigation provides data for a large part of the Idaho section. The Montana and Wyoming sections have not been studied in as much detail. However, all three sections are meteorologically, geologically, and hydrologically similar.

Groundwater

Almost all of the geologic units contain some groundwater, as described by Whitehead. Much of the water occurs under water table conditions (i.e. unconfined), although artesian conditions (confined) may occur. Unconsolidated alluvial and glacial materials along stream channels and in valleys are the more productive aquifers. These usually provide adequate yields to wells. Basalt aquifers are highly variable, but large yields can be obtained if fracture zones are penetrated. The rhyolitic ash flows (Yellowstone Group and Plateau Rhyolite) yield quantities sufficient for domestic purposes, but large yields are limited to places where flows are highly permeable. The known and estimated hydraulic properties of the various rocks and unconsolidated materials are presented in table 4.

Several hundred wells are in the IPGA. Except those in the Ashton area, most are concentrated along streams in areas of summer home development. Ashton has numerous wells for municipal, domestic, and livestock use. Only a few wells are used for irrigation. The residents of West Yellowstone use wells (in unconsolidated obsidian sands) primarily as a domestic water supply. Water levels are generally highest from June to September due to groundwater recharge from the melting snowpack. Lowest water levels occur in the early part of the year.

Idaho, Montana and Wyoming have established a water quality classification system for State surface water networks. The surface waters in the IPGA flowing on Federal lands fall under the water quality classification schemes of these States. Table 8 presents each State's surface water classification system.

TABLE 8. WATER USE AND QUALITY DESIGNATIONS IN THE ISLAND PARK GEOTHERMAL AREA: STATE CLASSIFICATION SYSTEMS FOR SURFACE WATER

	State Classification Grading Level	Basis for Classification	Uses to be Protected	Number of Streams in the IPGA in this Class
Idaho	A (highest of 3 classes)	Primary contact recreational waters in which bodily submergence and accidental swallowing of water may occur	Domestic and industrial water supply, irrigation, livestock watering, salmonid fish spawning and rearing, other fishing and aquatic life, hunting and wildlife, water skiing and swimming, pleasure boating, aesthetics	All
Montana	B-D1 (3rd highest of 8 classes)	Maintenance of quality for drinking, culinary and food processing purposes (after adequate treatment)	Bathing, swimming and recreation, growth and propagation of salmonid fishes and associated aquatic life, waterfowl, furbearers, agricultural and industrial water supply	All
Wyoming	II (2nd highest of 4 classes)	Support game fish or have the hydrologic and natural water quality potential to do so	(the 4 classes are based on fisheries quality, or potential; Wyoming seeks to protect the best possible quality of waters commensurate with the uses in or for; agriculture, fish and wildlife, industry, public water supply, recreation, scenic value)	All

Source: State of Idaho Water Quality Standards and Wastewater Treatment Requirements (June, 1973), and Idaho Water Quality Status (May, 1975); State of Wyoming Water Quality Rules and Regulations, Chapter 1, Quality Standards for Wyoming Surface Waters (May, 1978); State of Montana Water Quality Standards (undated, MAC 16-12.14 (10)-S 14480)

The chemical composition of surface water is dependent on the rocks with which it has come in contact. The general composition of surface water in the IPGA is as follows: calcium magnesium bicarbonate water drains from sedimentary rocks that include carbonates, calcium magnesium water drains from the basalts, and sodium potassium water drains from the rhyolite ash flows and lava. However, the surface water may have contacted more than one predominant rock type and thus represent a mixture of different waters (e.g. Henrys Fork near Ashton, table 9). Table 9 shows water chemistry for the three main drainages in the IPGA. Water quality for other drainages appears in Appendix D.

Turbidity and suspended solids have been studied in the surface water. While erosion is not a major problem in the IPGA, surface water quality is sometimes adversely influenced by logging activities, road construction near streams, grazing animals that trample streambanks, and dirt roads that channel surface runoff to streams. Turbidity is low in the Upper Henrys Fork drainage, averaging 1.4 Jackson turbidity units; suspended solids average about 7.5 mg/l. Limited sampling in the South Fork of the Madison River at the U.S. 191/20 highway bridge showed turbidity of zero Jackson units, and suspended solids of 2.7 and 4.9 mg/l (2 samples).

TABLE 9. SURFACE WATER CHEMISTRY FOR THREE DRAINAGES IN THE ISLAND PARK GEOTHERMAL AREA (mg/l except where noted)

	Headwaters			Lowest Parts of Drainages in the IPGA		
	So. Fork Madison River[1] (Montana)	Henrys Fork near Henrys Lake (Idaho)	Falls River[2] by Yellowstone National Park boundary (Wyoming)	So. Fork Madison River near US 191-20 highway bridge (Montana)	Henrys Fork near Ashton, Idaho	Falls River near edge of IPGA (Idaho)
Date sampled	9/7/77	9/8/77	9/21/77	10/5/77	9/6/77	9/7/77
Water Temp ° C	4.8	13.5	7.5	7.5	17.8	18.1
pH (field)	6.6	7.7	7.7	6.8	7.7	7.4
Specific conductance field) umhos/cm at 25° C	48	(lab) 187	200	85	159	210
alkalinity, total as $CaCO_3$	15	110	65	40	72	76
HCO_3	18	130	79	49	88	93
B, ug/l	6	—	360	50	50	310
Ca	5.2	19	6.8	7.6	14	5.5
CO_3	0	0	0	0	0	0
Cl	0.5	1.2	15	3.2	2.9	13
F	1.4	0.1	3.7	2.9	1.8	3.6
Hardness noncarb	2	0	0	0	0	0
Hardness, total	17	97	20	24	53	18
Mg	1.0	12	0.7	1.1	4.3	1.1
NO_2 and NO_3 as N dissolved	0.09	0.09	0.05	0.02	0.01	0.06
P total as P	0.01	0.03	0.01	0.00	0.03	0.01
K	1.5	1.4	3.9	1.8	2.1	3.8
TDS	46	105	158	86	105	164
SAR	0.2	0.1	3.4	0.8	0.6	3.7
SiO_2	24	1.7	51	34	23	51
Na	2.2	2.2	35	9.0	10	36
Na%	20	5	75	43	28	77
SO_4	0.9	2.7	2.5	1.9	3.8	3.4
Pesticides and Herbicides (19 total)	—	—	—	None detected in these surface water flows		

[1] Sampled at a headwater spring source in summer

[2] not headwaters; Falls River rises in Yellowstone National Park

Source: unpublished records of the US Geological Survey

Much is known about surface water quality in the Upper Henrys Fork basin from Whitehead's 1974 and 1975 work. Nitrogen and phosphorous are generally low, but show some seasonal variation and are troublesome in places. During the warm months, when biological activity is high, the concentrations are at their lowest levels, suggesting consumption by plant and animal life.

In parts of Henrys Fork and its tributaries above Ashton, algal and plant growths are common for part of the summer, although not at nuisance levels. However, nuisance growths do occur in Henrys Fork from near Last Chance to Osborne Bridge (map 5). The river is unshaded, wide, and fairly shallow in this reach and is downstream from most of man's influences in the upper part of the basin. Water temperature, also important to a stream's biologic activity, can remain over 20° C (68° F) in this reach for several days at a time under certain weather conditions.

Phytoplankton data from Henrys Lake and Island Park Reservoir indicate that the water bodies undergo yearly changes in fertility. Generally, in the spring after winter stagnation under ice cover the dominant algae are diatoms. When circulation improves with warmer temperatures and sunlight, blue-green algae, which are indicators of eutrophication, are dominant. Nutrient concentrations for water from Henrys Lake and Island Park Reservoir indicate an increase during the cold months, when blue-green algae production slows down, and a decrease during the season of productivity.

Hebgen Lake, north of the Montana part of the IPGA, is relatively warm and high in nutrients, with relatively high concentrations of arsenic and fluoride. The Madison River enters the lake from Yellowstone National Park and contains water high in dissolved minerals from many hot springs and geysers. The abundant nutrients stimulate seasonal algae growths creating a eutrophic condition (highly enriched).

Microbiological sampling done by Whitehead revealed that human and animal wastes affect the surface water at some sites, particularly during the summer. In July 1975, Henrys Fork above Island Park Reservoir had a combination of bacteria that indicates a predominance of human waste in a mixed animal and human source pollution. Henrys Fork near Ashton during the same period had bacteria indicative of wastes wholly or predominantly from animal sources.

Pesticides and herbicides have been used in the IPGA. In 1977, surface water was sampled for these substances in Henrys Fork, Falls River, and the South Fork of the Madison River at the IPGA boundary. No residual pesticide or herbicide was detected in this sampling (Table 9).

Boron is often found in waters draining from volcanic lands. Cultivated crops have varying sensitivities to boron in irrigation water. According to a U.S. Department of Agriculture study which rates crop tolerance to boron, the commercial crops grown downstream of the IPGA are either semi-tolerant (oats, wheat, barley and potatoes), or tolerant (alfalfa and sugar beets) to boron in irrigation water. This study has also rated the quality of the irrigation water with respect to boron concentration. For the water to be considered in the excellent grade class, the boron concentration must not exceed 0.67 mg/l for semi-tolerant crops, and must be less than 1.00 mg/l for tolerant crops. In Falls River where it leaves the IPGA, the concentration is 0.3 mg/l; in the South Fork of the Madison River and in Henrys Fork, where each river leaves the IPGA, the concentration is 0.05 mg/l.

Water Rights

The three states (Idaho, Montana, Wyoming) in the IPGA adhere to the Appropriation Doctrine, also known as the Colorado Doctrine. This states that the user on a water source who first applies the water to a beneficial use is entitled to the first water right on that source; other uses follow in succeeding order through time. "First in time is first in right" often expresses the purpose of the doctrine. Whenever a new water user applies for a water right, the State must decide if prior water rights will continue to receive their respective amounts of water. If the proposed new use interferes with existing rights, the State may disapprove the proposed new use.

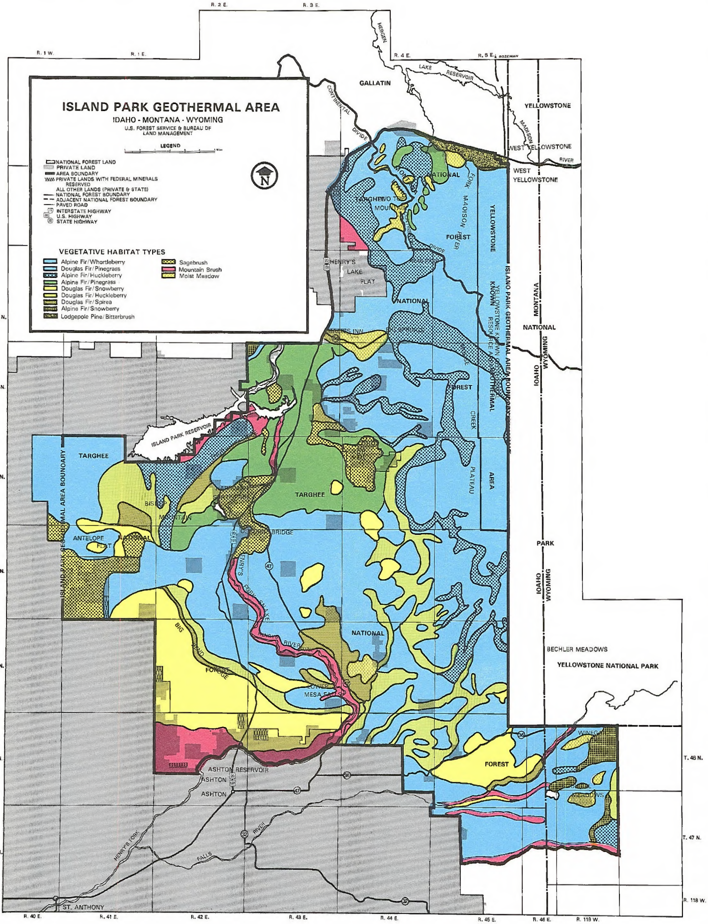
VEGETATION

Vegetation in the IPGA is within the Rocky Mountain Douglas-fir forest province. Vegetal habitat types are a result of complex interactions between elevation, temperature, moisture, aspect, and soils. Disturbances such as fire, logging, and grazing also affect the vegetation to varying degrees.

The major forest habitat types were identified and mapped (Map 6). A document describing the ecological relationships, species composition, coverage, etc. of each habitat type is on file with the Targhee National Forest. Table 10 is a summary of characteristics and percent of the total of each major habitat on the IPGA; rivers, streams, marshes, riparian, and unique habits (cliffs, caves, and talus) account for less than one percent of the area.

Riparian habitats are typified by sedges, rushes and grasses with a shrubby overstory of willows, dogwood, hawthorn and alder. Found along the edges of streams, ponds and poorly drained canyon and valley bottoms, riparian habitats are virtually flooded during spring runoff, but usually dry by mid-to late-summer. Riparian habitats, having a high capacity for filtering out sediment of overland flows from adjacent lands, are

6. HABITAT TYPES



also highly susceptible to overuse and easily disturbed. Studies have shown that because riparian habitats are extremely important to wildlife they receive more use per unit area than any other type. Of 253 species of wildlife known to occur on the IPGA, 193 (76 percent) are either directly dependent on riparian zones or use them proportionately more than any other site.

TABLE 10. CHARACTERISTICS OF VEGETATIVE HABITATS ON THE ISLAND PARK GEOTHERMAL AREA

Habitat (percent) of total IPGA)	General location on IPGA	Ecological characteristics	Characteristic plant species
Douglas-fir Series (42)	• Moderate elevations (5100-7200 feet) • Broad belt which merges with mountain brush and alpine fir series	• Warmest and driest Forest areas • Lodgepole pine presently dominates most sites • Alpine fir and spruce are accidental • Aspen sometimes dominates but on small areas • Lodgepole pine is under epidemic attack by mountain pine beetle	• Douglas-fir • Lodgepole pine • Quaking aspen • Snowberry • Spirea • Globe huckleberry • Meadowrue • Aster • Sticky geranium • Pinegrass • Elk sedge
Alpine fir Series (44)	• Borders Douglas-fir Series and extends to timberline or Continental Divide • Predominantly in eastern and southeastern portions next to Yellowstone National Park and the Teton range	• Cooler, damper sites • Lodgepole pine presently dominates and persists for longer time • Douglas-fir occurs in a seral role • Aspen, limber pine and spruce occur periodically • Lodgepole pine is under attack by pine beetle.	• Subalpine fir • Lodgepole pine • Quaking aspen • Douglas-fir • Limber pine • Engelmann spruce • Globe huckleberry • Grouse whortleberry • Snowberry • Spirea • Meadowrue • Lupine • Pinegrass • Elk sedge
Sagebrush-grass (6)	• Lower elevations, on dry, course-textured soil • Occurs largely on Bureau of Land Management lands in central and western portions • Also found scattered throughout the forested series on dry, rocky, windswept outcrops	• Sagebrush usually dominant • Scattered Douglas-fir along southern portion along ecotone with Douglas-fir series	• Big sagebrush • Threetip sagebrush • Snowberry • Woods rose • Knotweed • Sticky geranium • Bluebunch wheatgrass • Nevada bluegrass • Idaho fescue
Mountain brush (3)	• Found on lowest and driest sites • Borders the Douglas-fir series along southwestern border • Also found along river courses on dry, southwest-facing slopes	• Dominated by shrubs other than sagebrush although sagebrush is present	• Rocky Mountain maple • Chokecherry • Rabbitbrush • Big sagebrush • Serviceberry • Eriogonum • Aster • Bluebunch wheatgrass
Wet Meadow (3)	• Scattered throughout—predominantly in northern, central and southeastern portions • Found on sites with high water table, or where run-in or flooding is common	• Floristically and ecologically diverse • Highly susceptible to disturbance during growing season • Rate of recovery at higher elevations is slower than at lower sites	• Willow • Wyethia • Camass • Pondweed • Yampa • Bluegrass • Junegrass • Sedges • Rushes

Marshes occur on areas with very poor drainage, and usually are inundated during most of the growing season. The largest concentration is in the southeastern portion of the IPGA. This vegetation type can also be found in and along shallow potholes, meandering streams, and large water bodies. Typical plants include rushes, sedges, cattails, pondweed, mosses, and water lily.

Unique habitats (cliffs, caves, and talus) where little vegetation is found are widely distributed. Individually they occupy a small percentage of the total area and are restricted in location. Since unique habitats are a product of geologic processes, they cannot be artificially created or maintained.

Approximately 5 fires per year occur on the IPGA. About half are man-caused and half lightning-caused. Fires are usually less than ½ acre and less than 10% reach 10 acres. Most man-caused fires occur near developed areas (Island Park) and heavily used recreation sites and travel routes (popular trails, campgrounds, etc.). Lightning fires occur throughout the IPGA.

In the past, fire played a significant part in the structure and function of vegetative communities. Prior to 1920, large, infrequent fires occurred throughout the IPGA. Large expanses of lodgepole pine presently occupying most of the area resulted from fires which occurred at approximately 100-200 year intervals. After 1920 effective suppression techniques reduced fires of significant size. However, with the change in Forest Service fire policy and increased fire management planning, fire's role in portions of the IPGA may be expected to take a more natural course.

With the extensive downfall of lodgepole pine resulting from the mountain pine beetle attack, fuel loads in the IPGA are increasing rapidly. It is estimated that they will reach 50-75 tons per acre by 1982. This increase will be due to beetle-killed lodgepole pine which will fall and create "jackstraw" fuel and access hazards. The current salvage and fuel management program is alleviating this increased loading somewhat. Topographic and climatological conditions conducive to a large fire in lodgepole pine (steep terrain, high winds, high temperatures, and low fuel moisture) are infrequent, and the probabability of a large fire is low. Nevertheless, a large fire could threaten developments within the IPGA, necessitating fuel reduction around these improvements.

Threatened and Endangered Plants

The Endangered Species Act of 1973 authorized the Secretary of the Interior to designate threatened and endangered plants as well as animals. The Act also directed the Smithsonian Institute, in conjunction with other agencies, to prepare a list of plants considered endangered or threatened. This list was published by the Fish and Wildlife Service (Federal Register, Vol. 40, No. 127) in 1975.

In 1977 and 1978 a survey of the IPGA was conducted to determine the presence of any species on the Smithsonian list. The list in **Endangered and Threatened Plants of Idaho** by D.M. Henderson was also checked. No species on either list was found on the IPGA. The final report is on file with the Targhee National Forest.

CULTURAL RESOURCES

An overview of cultural resources was prepared for the Island Park Geothermal Area in October, 1977, to review existing information and to identify sites of historical or archaeological significance for future surveys. This report is filed in the Supervisor's Office, Targhee National Forest, St. Anthony, Idaho.

Prehistoric

Evidence from the IPGA and surrounding regions indicates that human occupation dates back at least 12,000 years. The consensus of archaeologists who have examined the region is that the IPGA was used seasonally or as a migration route. The exception to this was year-round occupation by the Tukudika or Sheepeaters, mountain Indians who were primarily hunters and did not travel as much as mounted tribes.

The eastern Shoshone (Snake) tribes were the most common summer migrants through the area. Other tribes which are thought to have spent some time in the area include Blackfeet, Crow, and Flathead.

Historic

During the summer of 1810, an expedition of trappers under the leadership of Andrew Henry became the first known white men to pass through the Island Park area. Until about 1840, trapping was an important activity in the area.

The first known white man to settle close to the IPGA was Gilman Sawtell who took up residence in about 1868 and developed a business taking fish from Henrys Lake and shipping them to markets in Montana and Utah.

In 1877 the Nez Perce Indians, led by Chief Joseph and retreating from U.S. Army pursuit, passed through Henrys Lake Flat and into Montana by way of Targhee Pass.

Many Indian campsites and most historic sites of early white settlers are located on private land.

Big Springs, the headwaters of Henrys Fork of the Snake River, was nominated for addition to the National Registry of Natural Landmarks, but has not yet been added to the register by the advisory committee.

RECREATION

The IPGA provides more than one million visitor days of yearlong recreation use annually, with an increase of about 5% per year. Recreational use occurs mainly along major roadways and water areas such as Island Park Reservoir and Henrys Fork of the Snake River.

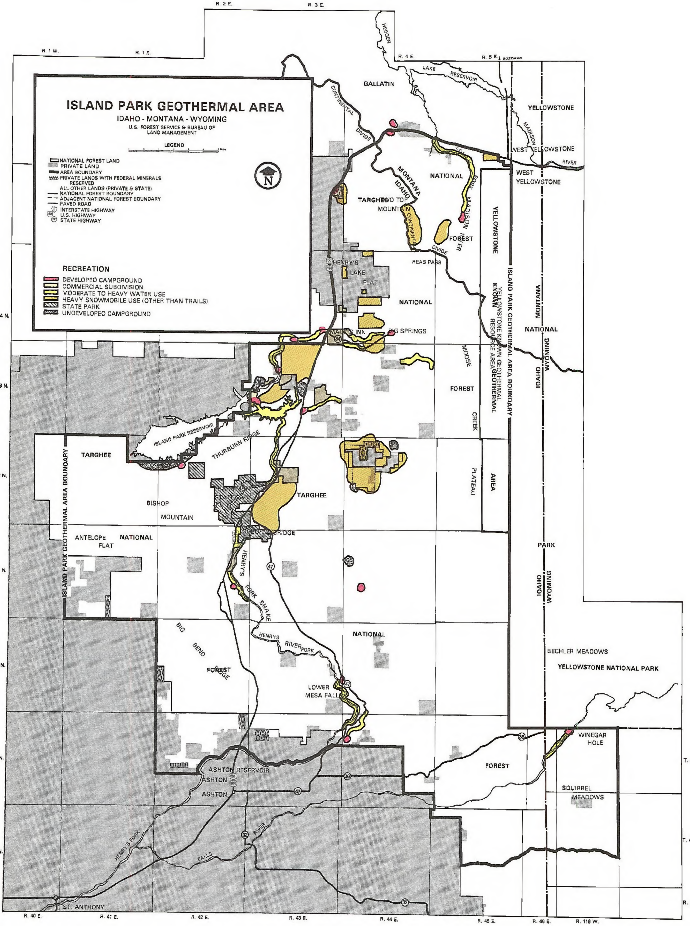
The IPGA is one of the most popular snowmobile areas in the intermountain west.

The IPGA contains large acreages of private land, much of which is being subdivided for recreational residences. Most are adjacent to Henrys Fork and U.S. Highway 20/191, near West Yellowstone, Island Park Reservoir of Henrys Lake. One area of unsubdivided private land is the Railroad Ranch, designated Harriman State Park in April, 1977. Most dispersed (non-concentrated) recreational activities are centered around snowmobiling, cross country skiing, fishing, boating, and water skiing. (tables 11 & 12)

More than 2,500 snowmobiles are registered in Fremont County, Idaho. This represents approximately 15% of the machines registered in the State and 33% of those registered in southeast Idaho. An estimated 70% of these registrations are by residents of other counties who register their machines in Fremont County to support the local trail grooming program. Winter weekend use in the IPGA often exceeds 2,000 snowmobiles per day. With the increased popularity of snowmobiling, recreational residences are being used year-round. A cooperative program between the Forest Service and Fremont County has established over 400 miles of groomed snowmobile trails.

Snowmobile use in the Gallatin National Forest portion of the IPGA near West Yellowstone, Montana, is extensive. A snowmobile racing oval located on National Forest lands southwest of West Yellowstone is used many times each winter for competitive events. A number of motels in West Yellowstone offer daily snowmobile tours which primarily use groomed trails on National Forest lands.

7. RECREATION USE



Volume of recreational use is primarily a product of access to points of interest. U.S. Highway 20/191 traverses the IPGA and enables high volume recreational use. This highway is a main artery for traffic through the West Yellowstone gate of Yellowstone National Park. The 1967 Yellowstone Park travel survey (assumed to also indicate present use) indicates that 25% of all visitors entered the Park through the West Yellowstone gate and 27% of all visitors exited there. Projections in the Greater Yellowstone Transportation Study indicate that by 1985, the Park will annually receive three million visitors. If use of gates is the same then, more than 1.5 million visitors will either enter or exit through the West Yellowstone gate. A high percentage of these visitors will traverse the Island Park Geothermal Area.

Recreational use considerations are shown on Map 7.

TABLE 11. SUMMER RECREATION USE OF FEDERAL LANDS IN AND ADJACENT TO THE ISLAND PARK GEOTHERMAL AREA

	TARGHEE NATIONAL FOREST	GALLATIN NATIONAL FOREST	BUREAU OF LAND MANAGEMENT LANDS	YELLOWSTONE NATIONAL PARK*
Developed Sites	Close to Island Park Reservoir, Henrys Fork of Snake River, Fall River	None	None	None
Undeveloped Sites	Close to streams and rivers—widely distributed	Close to S. Fork of Madison River	East of Island Park siding	Cave Falls Area, S.W. corner of Park
Dispersed Activities				
a. Hiking (also backpacking)	a. Lionhead Mtn. Area, Two-Top Mtn. Area, Henrys Fork of Snake River	a. South fork of Madison River	a. None	a. Bechler Meadows Area, Boundary Creek (s.w. park)
b. Recreational Vehicle Riding	b. Woods roads throughout area	b. Adjacent To West Yellowstone and on woods roads	b. Primarily in S.W. portion of area & near Island Park siding	b. None
c. Fishing	c. Lakes Rivers & Streams throughout	c. S. Fork of Madison River and Hebgen Lake	c. Ashton Reservoir, Henrys Lake Outlet	c. Fall River, Bechler River
d. Viewing	d. Along primary transportation routes	d. Along U.S. 20 & S. Fork of Madison River	d. Henrys Lake Flat, Ashton Reservoir	d. Cave Falls Area of S.W. Park

* Not in IPGA, but use immediately adjacent to area is important to leasing considerations.

TABLE 12. WINTER RECREATION USE OF FEDERAL LANDS IN AND ADJACENT TO THE ISLAND PARK GEOTHERMAL AREA

	TARGHEE NATIONAL FOREST	GALLATIN NATIONAL FOREST	BUREAU OF LAND MANAGEMENT	YELLOWSTONE NATIONAL PARK*
Developed Sites	Bear Gulch Ski Area	Snowmobile Racing Oval S.W. of West Yellowstone	None	None
Concentrated Use (Snowmobiles)	Island Park Siding, between Coffee Pot Rapids & Island Park Reservoir, & Big Springs Area	Just west of W. Yellowstone, Indian Creek & head of S. Fork of Madison River	Island Park Siding, Meadow Creek & Henrys Lake Flat	Hwy. through West Entrance
Dispersed Activities				
a. Cross Country Skiing	a. Warm River Area, Bear Gulch, Buffalo River, adjacent to commercial development	a. S.W. of West Yellowstone on groomed trails	a. Little Use	a. Along Madison River East of West Yellowstone
b. Snowmobiling	b. All groomed trails & many ungroomed roads throughout entire area	b. Groomed trails south of West Yellowstone	b. Trails on west side of IPGA	b. None

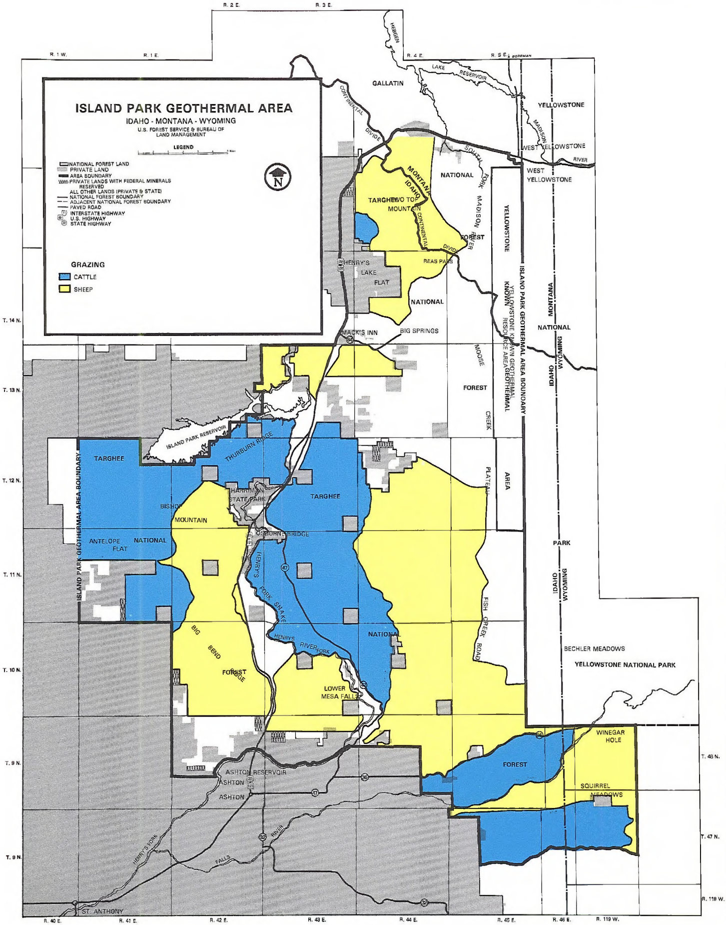
* Not in IPGA, but use immediately adjacent to area is important to leasing considerations.

GRAZING

Forage used by livestock contributes significantly to the economies of communities adjacent to the Island Park area. This forage, an important part of many livestock operations, provides summer grazing necessary to maintain viable year-long operations.

Water development structures (troughs, impoundments), and more than 120 miles of range fencing help control livestock distribution and forage utilization.

Approximately 4,300 head of cattle and 15,000 head of sheep use forage within the IPGA. The extent of grazing is shown on map 8. Table 13 summarizes forage use.


ISLAND PARK GEOTHERMAL AREA
IDAHO - MONTANA - WYOMING
U.S. FOREST SERVICE & BUREAU OF LAND MANAGEMENT
LEGEND
NATIONAL FOREST LAND
PRIVATE LAND
AREA BOUNDARY
PRIVATE LANDS WITH FEDERAL MINERALS RESERVED
ALL OTHER LANDS (PRIVATE & STATE)
NATIONAL FOREST BOUNDARY
ADJACENT NATIONAL FOREST BOUNDARY
PAVED ROAD
INTERSTATE HIGHWAY
U.S. HIGHWAY
STATE HIGHWAY
GRAZING
CATTLE
SHEEP
GALLATIN
YELLOWSTONE
WEST YELLOWSTONE
HEBGEN LAKE RESERVOIR
CONTINENTAL DIVIDE
TARGHEE
MONTANA
IDAHO
NATIONAL
FOREST
SOUTH FORK MADISON RIVER
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MACK'S INN
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ISLAND PARK RESERVOIR
THURBURN RIDGE
BISHOP MOUNTAIN
HARRIMAN STATE PARK
OSBORNE BRIDGE
ANTELOPE FLAT
HENRY'S FORK SNAKE
HENRYS FORK RIVER
BIG BEND RIDGE
LOWER MESA FALLS
FISH CREEK ROAD
BECHLER MEADOWS
YELLOWSTONE NATIONAL PARK
WINEGAR HOLE
SQUIRREL MEADOWS
ASHTON RESERVOIR
ASHTON
FALLS RIVER
ST. ANTHONY
WYOMING
PARK

TABLE 13. GRAZING SUMMARY FOR THE ISLAND PARK GEOTHERMAL AREA

	Allotments	Permittees	Acres	Use Season	Animal Unit Months (AUMS)*
CATTLE					
National Forest Lands	8	20	145,353	June-Sept.	12,284
BLM Lands	6	8	6,437	June-Oct.	1,158
SHEEP					
National Forest Lands	17	11	204,558	Late Mid June-Sept.	29,103
BLM Lands	2	2	400	June-Sept.	300

*An AUM (Animal Unit Month) is the quantity of forage required by one mature cow (1,000 lbs.) or the equivalent for one month. One month's forage for five mature ewes (sheep) equals one AUM.

The IPGA provides valuable summer grazing for cattle and sheep.

WILDLIFE

The terrestrial wildlife communities inhabiting the IPGA result from vegetative patterns and man's activities. Although the vegetative designs of the IPGA appear homogeneous and unchanging, they are in fact dynamic systems constantly undergoing change through time. Wildlife associated with these communities also change in number, distribution, and composition.

Although much information is available on some animal species, little is available on others. Most information deals with wildlife management units not conforming to the boundaries of the IPGA. When possible, information has been quantified. However, in most cases, dissimilar data had to be combined to arrive at a species final standing in the IPGA. To the extent possible, animals are discussed as individual species or groups of similar species.

A total of 5 amphibians, 8 reptiles, 179 birds, and 61 mammals were identified according to habitat affinity and seasonal use. Migrant and accidentally occurring species were included in the appendix. Species were oriented to a habitat if they used that type for reproduction and feeding. The complete matrix is on file with the Targhee National Forest. Table 14 is a partial listing of the number of habitats used by common species and those of special interest (Appendix E contains a summary of all species).

TABLE 14. SOME COMMON AND SPECIAL INTEREST (*) WILDLIFE SPECIES AND NUMBER OF HABITATS EACH USES. SEE TABLE 15 FOR DIFFERENT HABITATS.

Chorus frog	6
Leopard frog	19
*Rubber boa	21
Racer	20
Common garter snake	23
*Western grebe	13
Great blue heron	19
*Black-crowned night heron	5
*American bittern	4
*Trumpeter swan	19
Canada goose	12
Mallard	23
Gadwall	15
Pintail	16
Blue-winged teal	12
Baldpate	15
Northern shoveler	15
Redhead	16
*Canvasback	11
Turkey vulture	25
*Sharp-shinned hawk	23
*Cooper's hawk	24
Red-tailed hawk	27
*Swainson's hawk	21
*Ferruginous hawk	5
*Golden eagle	29
*Bald eagle	23
*Marsh hawk	10
*Osprey	17
*Prairie falcon	7
*Merlin	23
*American kestrel	25
Blue grouse	25
Ruffed grouse	20
*Sharp-tailed grouse	8
*Sage grouse	6
Sandhill crane	14
Common snipe	14
Spotted sandpiper	11
American avocet	12
California gull	11
Mourning dove	17
*Barn owl	17
Great horned owl	24
*Burrowing owl	4
*Short-eared owl	14
Common nighthawk	22
Calliope hummingbird	18
Belted kingfisher	17
Common flicker	21
*Lewis woodpecker	21
Yellow-bellied sapsucker	15
*Hairy woodpecker	19
Eastern kingbird	19
Western tanager	21
Hammond flycatcher	19
Western wood pee-wee	18
Olive-sided flycatcher	22
Horned lark	7
Tree swallow	24
Bank swallow	17
Gray jay	19
Black-billed magpie	21
Common raven	23
Clark's nutcracker	16
Black-capped chickadee	25
Red-breasted nuthatch	18
Brown creeper	14
Dipper	20
Canyon wren	15
American robin	26
Mountain bluebird	26
Golden-crowned kinglet	14
*Loggerhead shrike	10
Starling	10
*Warbling vireo	11
*Yellow warbler	5
Yellow-rumped warbler	23
*Yellow-breasted chat	16
House sparrow	7
Western meadowlark	7
Yellow-headed blackbird	6
Red-winged blackbird	7
Northern oriole	14
Brewer's blackbird	15
Evening grosbeak	19
House finch	19
Pine siskin	22
Green-tailed towhee	11
*Vesper sparrow	4
Dark-eyed junco	18
Brewer's sparrow	5
White-crowned sparrow	24
Vagrant shrew	24
Little brown myotis	23
Silver-haired bat	19
Big brown bat	25
Pika	5
Snowshoe hare	18
Least chipmunk	19
Yellow pine chipmunk	25
Yellow-bellied marmot	12
Richardson's ground squirrel	2
Red squirrel	18
Northern pocket gopher	24
Beaver	24
Deer mouse	31
Boreal red-back vole	12
Mountain vole	20
Muskrat	10
Western jumping mouse	17
Porcupine	25
Coyote	30
*Gray wolf (Northern Rky. Mtn. Wolf)	27
Black bear	31
*Grizzly bear	27
Marten	14
*Fisher	21
Long-tailed weasel	30
Mink	26
*Wolverine	17
Badger	16
Striped skunk	18
*Canada lynx	19
*Bobcat	26
Elk (Wapiti)	24
Mule deer	23
Pronghorn	25
Moose	25

The number of habitats each species uses for feeding and reproduction is a measure of the adaptability of the species. The greater the number of habitats used the more adaptable the species and the less vulnerable it is to habitat manipulation or loss. The more species using the habitat for feeding and reproduction, the more important it is to wildlife. Table 15 gives a summary of the wildlife-habitat associations.

Analysis of wildlife in the preceding manner does not allow consideration of certain key components of important wildlife groups (winter range, migration routes, reproduction areas, legal considerations, etc.). The following discussion considers key points for species or groups of special interest on the IPGA.

The IPGA does not conform to State Fish and Game Department big game management units, herd units, or hunting districts. Approximately 85% of the IPGA is within portions of Idaho Management Units 60, 61, 62, and 62A, none of which lie entirely within the area. Data collected for these four units, when adjusted to include portions in Montana and Wyoming, reflect features of the big game populations that inhabit the IPGA as a whole. In most cases, available data on big game within the Montana and Wyoming units are identical or very similar to Idaho information.

TABLE 15. WILDLIFE-HABITAT ASSOCIATIONS BASED ON REPRODUCTION AND FEEDING. AF=SUBALPINE FIR: DF=DOUGLAS-FIR; LPP=LODGEPOLE PINE.

Habitat	Number of wildlife species using habitat for: Reproduction	Feeding	Total number of species using habitat
AF/Snowberry	122	141	142
DF/Snowberry	130	160	162
AF/Spirea	121	142	143
AF/Huckleberry	99	106	108
AF/Whortleberry	90	95	96
AF/Pinegrass	94	105	106
DF/Huckleberry	137	162	163
DF/Pinegrass	133	168	168
DF/Spirea	90	116	143
DF/Mountain Maple	127	148	149
LPP/Bitterbrush	72	73	74
Forest Successional Stage			
Grass-Forb	57	164	165
Shrub-seedling	85	175	175
Seral pole	83	150	151
Full-size seral	128	142	152
Full-size climax	125	133	143
Old growth	113	127	136
Aspen Groves	77	123	126
Sagebrush	68	103	103
Mountain brush	71	103	104
Dry Meadows	41	122	122
Wet Meadows	48	128	128
Rivers & Streams	132	192	193
Lakes & Reservoirs	82	144	144
Riparian Deciduous	123	170	176
Marshes	109	148	152
Cliffs & Rims	39	48	62
Talus	23	59	61
Caves	21	10	25
Snags	44	43	58
Down Material	45	73	84

Information on small game and waterfowl was collected by counties and an estimate was made of the proportion occurring on the IPGA. In all cases wildlife population projections and goals are presented and, when relevant, past trends are discussed.

Big Game

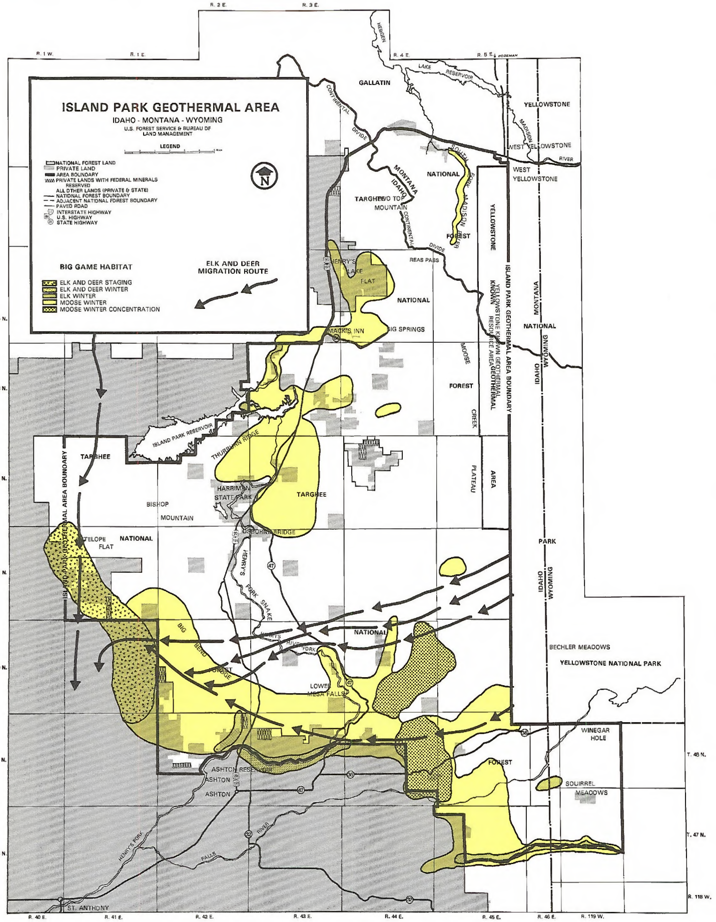
Elk (Wapiti) have long been an important game animal on the IPGA. Their occurrence on the area depends mainly upon the presence and condition of their food supply. Their numbers have varied, but the present population is increasing after a 10-15 year low (Table 16).

TABLE 16. PRESENT AND FUTURE STATUS OF BIG GAME ON THE ISLAND PARK GEOTHERMAL AREA

	Year	Population	Harvest	Demand (Hunter Days)	Success (Days/Animal)
Elk (Wapiti)	1975	1,700	275	12,712	40.6
	1980	1,920	375	15,750	38.1
Mule Deer	1975	2,700	525	6,220	13.3
	1980	2,300	295	6,000	12.5
Moose	1975	320	22	84	4.7
	1980	200	4	20	5.0
Black Bear	1975	430	25	845	30.8
	1980	465	35	1,630	48.0

Source: Idaho Department of Fish and Game

9. WILDLIFE MIGRATION ROUTES



Most elk migrate by late November and congregate on a major staging area in the southwestern portion of the IPGA (Map 9). Much of this staging area is on adjoining lands administered by the Bureau of Land Management and the State of Idaho. Approximately 35% is on the IPGA. The specific function of this staging area is unknown; however, animals spend most of the time feeding, apparently preparing for winter. During mild winters they use the area for winter range.

In summer elk are distributed throughout the IPGA. Habitat use patterns vary with climate and various activities in the area (grazing, logging, recreation, etc.). The entire IPGA is fair summer range for elk. Elk wander back and forth across the Yellowstone National Park boundary throughout the summer.

Elk migrate along distinct routes through the IPGA (Map 9). Elk from Yellowstone National Park and surrounding portions of the Targhee and Gallatin National Forests also use these routes, but the exact numbers or proportions of these herds using the routes are unknown. In the northeastern portion of the IPGA east of the Continental Divide, elk from the Madison River herd in Yellowstone National Park migrate and spend the fall and winter along the South Fork of the Madison River. Here, no distinct migration routes have been identified.

By mid-December elk have moved to the Juniper Mountains/Sand Dunes winter range approximately 30 miles southeast of the IPGA. This winter range is administered by the Bureau of Land Management and the Idaho Fish and Game Department in cooperation with the Department of Lands and private landowners. Most of the elk that summer on the IPGA spend the winter on this range. In the winter of 1977-78, the winter range held approximately 1,500 elk, 200 more than the previous winter. Herd productivity rates have ranged from 45 to 76 calves per 100 cows over the last three years. The Idaho Fish and Game Department has set a goal of achieving an optimum herd size of 2,000 by 1980.

Approximately 200 elk winter on the IPGA (Map 9). The winter ranges, located along Boone Creek and Conant Creek in the southeastern portion and along Willow Creek in the Southwest, are in fair to poor condition with much of the winter browse overused, old, and decadent. The Idaho Fish and Game Department fed 103 elk on an emergency basis along the southwestern border of the IPGA during the 1977-78 winter.

Since 1974 hunting in Idaho has been "bulls only" during general seasons, with fewer special permits, fewer general hunts, and shorter seasons. Some either sex permits issued during special hunts within the IPGA will continue to be issued in the future. In the Montana portion of the IPGA, hunting is also "bulls only", with some permits for antlerless elks. Wyoming allows late either sex hunts on its elk within the IPGA.

There are no discrete elk calving grounds on the IPGA. Calving occurs on the winter, spring, and summer range and is totally dependent upon climate. In years with heavy snowfall and a "late" spring, calving takes place off the IPGA or along the western and southwestern edges. In years with light snowfall, elk may calve anywhere on the IPGA in suitable habitat. However, key calving areas (those used every year of "normal" snowfall) are along Big Bend Ridge and Thurburn Ridge.

The mule deer is the most important big game species in Idaho, Wyoming, and Montana in terms of total animals harvested and hunter participation. The entire IPGA is summer range in fair to good condition with good summer range in short supply.

Present deer numbers are low (Table 16) due to several factors: mule deer populations have fluctuated over the past 100 years with variations in habitat, climatic conditions, reproductive success, and fawn/yearling survival. Low deer numbers are not limited to Idaho or the IPGA, as adjacent States have indicated that deer herds are below desired levels and have declined for the past several years.

Most of the mule deer that summer on the IPGA spend the winter off the area. The main winter range is the Juniper Mountains/Sand Dunes range described above. Approximately 1,200 deer used this range in the winter of 1977-78. Numbers have ranged from 700-1,100 in the past 5-10 years. Deer use the migration routes described earlier (Map 9), and fawning occurs along these routes. In 1977 a ground count by the Idaho Fish and Game Department estimated a production of 70 fawns per 100 does along Big Bend Ridge. Some deer winter on the IPGA along the southern boundary (Map 9). In the winter of 1977-78, approximately 70-80 deer were emergency-fed by the Idaho Fish and Game Department along the Ashton Hill and Warm River in order to pull them through this particularly harsh winter. Some feeding occurs on private land each year.

Moose are distributed throughout the IPGA with variable patterns of habitat use. During the summer small groups (2-5) and single individuals are scattered through the various habitats. Moose prefer forest, mountain brush, and riparian habitat types. Willow areas within the riparian type receive considerable use.

Previous high density moose populations in the IPGA have declined severely in the past five years. Wintering numbers have decreased due to winter mortality, uncontrolled Indian harvest, and illegal kills. The Idaho Fish and Game Department no longer allows hunting of moose within the Idaho portion. The Wyoming Game and Fish Department has reduced the number of permits in the herd unit overlapping the IPGA. Moose are still hunted in the Montana portion, but current hunter success is declining.

The IPGA provides extensive winter range for moose (Map 9). The condition of ranges varies throughout the area, but in most portions is good. The main winter areas are: (1) Fall River-Warm River Butte, which receives heavy use during extreme winters and is rated fair to poor winter range. Moose in portions of this area reach densities of 10-20 animals per square mile. Most move into Yellowstone National Park and Wyoming during the summer. (2) Big Bend Ridge—this range is in good condition, but the population has been declining, possibly due to illegal harvest. The main concentration areas are Snake River Butte and drainages. (3) Island Park-Henrys Lake—the main areas of use are along Henrys Fork with scattered use in the Henrys Flat region. This range is also considered good. Approximately 30-40 moose winter along the south shoreline of Island Park Reservoir utilizing willow-covered peninsulas. Some of these animals range into the IPGA and utilize forested habitats, but the degree of use has not been determined. (4) Hebgen Lake—this range, located along the South Fork of the Madison River and in riparian areas along the Henrys Lake Mountain, is considered good range.

Snow depth in the IPGA in extreme winters can be a problem to moose. They are able to get along in deep snow, but depths of six and seven feet can increase mortality of old and young animals. Food availability determines winter range selection and overall well-being of the herds. Important forage species include willow, bitterbrush, chokecherry, serviceberry, subalpine fir, sedges, and grasses.

Black bear reach highest numbers in the eastern half of the IPGA; however, they are present throughout the area. Despite a continual open season and indiscriminate killing, densities remain high in certain portions, especially the southeastern section. No information is available on reproductive rates, sex ratios, or other population parameters. Studies to be completed in 1979 by the Targhee National Forest are expected to fill some of these voids.

The mountain lion is present in the IPGA, but its status and numbers are unknown. Total numbers are undoubtedly low since the area is less than optimum habitat. They are currently protected in Idaho and hunted on a limited basis in Wyoming and Montana.

Pronghorns (antelope) use Henrys Lake Flat in the northwestern corner of the IPGA. This is predominantly private grassland used for livestock grazing, with small pockets of sagebrush throughout. The Idaho Fish and Game Department estimates that 180 pronghorn use the summer range in and around Henrys Lake Flat, approximately one-half of which is on the IPGA. The herd migrates through Raynolds Pass into Montana for the winter. Pronghorns are not presently hunted on the IPGA.

Upland Game

The importance of upland game birds is tabulated in table 17. Upland game hunting is a significant use of wildlife on the IPGA.

Sage grouse use sagebrush-grass and mountain brush habitats for summer feeding and brood rearing (map 10). Preferred habitats are associated with stream bottoms where water and meadows with succulent vegetation are available for brood rearing. The closest strutting grounds to the IPGA are approximately five miles southwest of the area. Preferred nesting habitat is usually within a two mile radius of the strutting grounds. No nests have been found on the IPGA. Despite annual fluctuations, sage grouse populations generally have increased since 1960. A peak was reached around 1970, and a decline was evident by 1975. It is projected that populations will gradually rebuild through 1990, with greater hunter demand and essentially the same hunter success rate (table 17).

Sharp-tailed grouse are rare on the IPGA with most sightings in mountain brush along the southwestern edge of Big Bend Ridge. They are associated largely with grasslands interspersed with brush. The sharp-tailed grouse is a species of special concern to the Idaho Fish and Game Department, which recommends that all possible measures be taken to protect, enhance, and expand existing habitat. In recent years, some increased since 1960. A peak was reached around 1970, and a decline was evident by 1975. It is projected that populations will gradually rebuild through 1990, with greater hunter demand and essentially the same hunter success rate (table 17).

Two species of forest grouse, blue and ruffed grouse, are common throughout the IPGA. Blue grouse use most habitats and move to higher elevations for wintering. They nest on grassy open slopes and sagebrush-covered ridges, usually at the base of a small tree or shrub. Nesting habitat is usually found at elevations below the mature coniferous forest used for wintering. They depend on conifer needles for winter food and have been known to gain weight on this diet.

Ruffed grouse are also found in most habitats on the IPGA. Although these birds eat a variety of food during much of the year, they feed largely on buds of aspen and various other deciduous species during the winter.

TABLE 17. UPLAND GAME BIRD STATISTICS FOR THE ISLAND PARK GEOTHERMAL AREA

Year	Pre-season Population	Total Harvest	Total Hunters	Total Hunting Days	Success (Birds/Day)
		SAGE GROUSE AND SHARPTAILED GROUSE			
1975	5,500	600	330	790	0.8
1980	5,600	680	340	800	0.8
1985	5,760	860	360	800	1.0
1990	6,000	1,000	400	1,000	1.0
		FOREST GROUSE			
1975	40,000	2,100	700	2,800	0.8
1980	45,000	2,600	1,000	4,000	0.7
1985	45,000	3,000	1,200	4,800	0.6
1990	45,000	3,800	1,500	6,000	0.6
		MOURNING DOVE			
1975	2,000	345	35	117	2.9
1980	2,000	360	40	130	2.8
1985	2,000	380	48	160	2.4
1990	2,000	400	50	170	2.4

Source: Idaho Fish and Game Department

Populations of forest grouse typically fluctuate and may be cyclic. Allowing for these fluctuations, past populations have been relatively stable, and this trend is expected to continue through 1990 (table 17). Most forest grouse are harvested coincidental to big game hunting although bird hunting is increasing in popularity. Due to this growing demand, harvest levels have steadily increased. Demand and harvest are both projected to continue increasing through 1990, with a constant hunter success rate.

The mourning dove is common throughout the IPGA; migratory and nesting populations are present. It is associated mainly with sagebrush-grass, mountain brush, and riparian habitats, but also occurs in some forested habitat types. Mourning dove populations gradually increased from 1960 through 1975. Under current management levels and habitat trends, populations should remain at present levels through 1990 (Table 17).

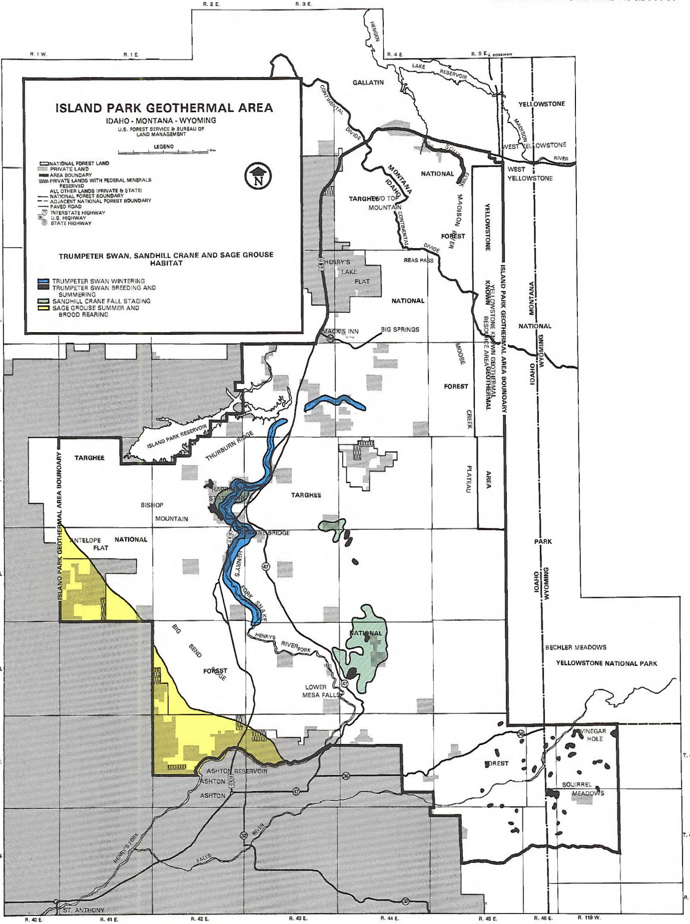
Mourning doves fall under the jurisdiction of the Migratory Bird Treaty Act. Under this Act, harvest regulations and management are primarily the responsibility of the U.S. Fish and Wildlife Service. The earliest opening date allowed under this Act is September 1, which coincides with the peak of migration out-of-state and effectively limits hunting.

Mountain cottontails (rabbits) are associated primarily with nonforested habitat, aspen groves, and riparian habitats. Essentially stable populations of the last 10-15 years are projected to remain so through 1990. Less than 20 cottontails are harvested in any year on the IPGA. Cottontails are a main constituent in the diet of many raptorial birds.

Waterfowl

The IPGA is located in the Pacific waterfowl flyway. Over a million waterfowl migrate over the IPGA in spring and fall. Fall movements begin in mid-to-late-August and continue through December. Large numbers of ducks and geese concentrate on and around Island Park reservoir, Henrys Lake, Hebgen Lake, and Harriman State Park before moving south. These concentration areas are immediately adjacent to the IPGA and Red Rock Lakes Migratory Waterfowl Refuge in Montana, only 15 miles to the northwest. Migrating waterfowl also make extensive use of Henrys Fork and other watercourses, lakes, marshes, and potholes on the area. The northward migration begins in late March and continues through April and May.

10. SAGE GROUSE, TRUMPETER SWAN, AND SANDHILL CRANE HABITAT



Resting and feeding habitat on the IPGA for migrating waterfowl is currently adequate to support the numbers passing through or overwintering. These conditions are not expected to change through 1990. Numbers of migratory birds are dependent upon production in out-of-state areas, primarily Canada. Despite annual fluctuations, numbers have been generally stable. Populations of migratory ducks are expected to decrease as a result of current management and habitat trends. With growing hunting demands, harvests and success rates will decrease.

Though waterfowl do breed and produce young on the IPGA most are produced outside the area. The best production areas are bodies of water such as beaver ponds, large and small streams, and marshes. Key concentration areas include Harriman State Park, Island Park Reservoir and surrounding areas, and the southeastern corner of the IPGA.

Allowing for normal fluctuations, the number of ducks produced on the IPGA has remained relatively constant since 1960. Harvests vary with duck populations and hunter numbers; success rates are projected to persist through 1990 (Table 18).

Photo courtesy of Sam Winegardner

Canada geese breed in most of the non-forested and riparian habitats on the IPGA. Nesting occurs primarily along rivers and streams, small lakes, and potholes. Many migrating geese use the IPGA for nesting and feeding. Numbers have generally increased since 1960. Migratory goose populations and harvests are expected to increase through 1990 (Table 18). The Idaho Fish and Game Department has a major effort underway to create new and improved nesting and rearing habitat. As part of this effort nesting platforms have been installed on Island Park Reservoir.

Raptors

A survey of birds of prey on the IPGA was done by the U.S. Fish and Wildlife Service in 1977. Their report detailing nest locations, breeding territories, reproductive effort, and diversity of raptors is on file with the Targhee National Forest. It indicates that 31 species of raptors use the area during some portion of the calendar year. Appendix E has a list of these birds and their habitats.

TABLE 18. PRESENT AND FUTURE WATERFOWL STATISTICS FOR THE ISLAND PARK GEOTHERMAL AREA

Year	Pre-season Population	Total Harvest	Total Hunters	Total Hunting Days	Success (Birds/Day)
			DUCKS		
1975	13,500	1,000	165	660	1.5
1980	13,500	1,100	175	720	1.5
1985	14,500	1,200	180	800	1.5
1990	15,000	1,400	200	900	1.6
			CANADA GEESE		
1975	1,500	450	360	1,080	0.4
1980	1,500	480	390	1,365	0.4
1985	1,500	525	420	1,640	0.3
1990	1,500	540	435	1,780	0.3

Source: Idaho Department of Fish and Game

Birds of prey subsist mainly on small rodents, fish, reptiles, amphibians, carrion, and an occasional hooved animal (ungulate). Shrubs, trees, and cliffs provide cover and nesting sites for most of the species. In open country around Henrys Lake Flat utility poles, fence posts, snags, and other isolated structures provide important perches for nesting and hunting. Many of these structures are also found around sagebrush flats, meadows, and riparian habitats on the IPGA. Raptors are important elements in predator-prey relationships in most ecosystems. They can help control small prey species such as rabbits, hares, and rodents.

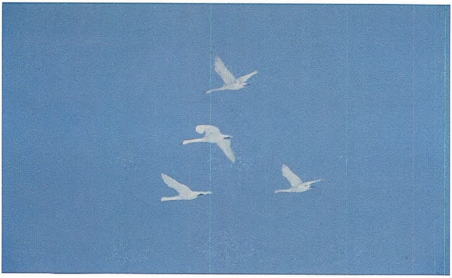
The Fish and Wildlife Service raptor report emphasized the importance of Henrys Lake Flat, which extends onto the IPGA. This high elevation grassland is used by hundreds of fledged falcons and hawks as a staging area during migration in August and September. Nearby ridges funnel birds in from the north, south, and west to the Flats, where they use the surrounding forest for hunting, roosting, and perching.

Raptors are completely protected by the Federal Migratory Bird Treaty Act and state regulations.

Species of Special Concern

Of special concern to Idaho, Montana, and Wyoming are species whose restricted range, specific habitat requirements, and/or low numbers make them vulnerable if adverse impacts on populations or habitat occur. Of the 22 state-listed species, the following are found on the IPGA: grizzly bear, Northern Rocky Mountain wolf, Canada lynx, fisher, wolverine, trumpeter swan, sharp-tailed grouse, ferruginous hawk, prairie falcon, American peregrine falcon, and northern bald eagle. The sharp-tailed grouse, ferruginous hawk and prairie falcon were discussed in previous sections, and those on the federal Threatened and Endangered Species List (wolf, grizzly bear, peregrine falcon, and bald eagle) are discussed in a separate section. The others are briefly discussed below.

The bobcat, Canada lynx, fisher, and wolverine are common-to-rare mammalian predators whose numbers have declined in the past 10-15 years. Rising prices for bobcat and lynx pelts and uncontrolled harvest have reduced their numbers drastically. They have been removed from predator lists and placed under Idaho Fish and Game Department's control. The fisher, requiring forested, wilderness habitat, is also under state control. The wolverine, which also requires wilderness habitat, is extremely rare in the IPGA.



The IPGA is a very important wintering area for Trumpeter Swans.

The trumpeter swan is a common resident of the IPGA (Map 10). While the species is no longer endangered or threatened, in recent years trumpeter breeding populations have experienced extremely high mortality among cygnets (60%-90%). Evidence points to a possible nutritional problem in the wintering areas. Breeding habitat requirements of these birds are:

1. Waters with a relatively static level, not marked by seasonal fluctuations.
2. Quiet waters of lakes, marshes, or sloughs, not subject to current or constant wave action.
3. Shallow waters of lakes or open marshes, not so deep as to preclude digging and foraging for lower aquatic plant parts, roots, tubers, etc.
4. Minimum human disturbance and relatively remote areas.

The open waters of the Henrys Fork drainage within the IPGA are the primary wintering areas for all of Canada's Trumpeter Swans. In addition to the migrants, approximately 50% of the year-round resident Trumpeters winter within the IPGA. The relative isolation, abundant submerged vegetation, and open waters of the Henrys Fork are critical to the welfare of the remaining Trumpeter population of Canada and the U.S. Hebgen Lake, approximately 4 miles north of the IPGA, also supports wintering Trumpeters.

Photo courtesy of Sam Winegardner

Several locations in the IPGA provide suitable Sandhill Crane habitat.

The sandhill crane, considered unique, is common on the IPGA. It is a summer resident which breeds and nests where there are abundant marsh and riparian habitat. Cranes congregate on a major staging area on the IPGA (Map 10) where they feed and prepare for the fall migration.

Threatened and Endangered species

The Endangered Species Act of 1973 (P.L. 93-205) officially recognizes two categories of animals, Endangered Species and Threatened Species. Section 7 requires all federal agencies to take necessary actions to insure critical habitat for endangered or threatened species is not adversely modified or destroyed.

Three endangered and one threatened species inhabit the IPGA. Although most wildlife species lists and maps show the range of the endangered spotted bat (**Euderma maculata**) extending into the IPGA, no authenticated records of spotted bats have been collected.

The Northern Rocky Mountain wolf (**Canis lupus irremotus**), one of 32 subspecies or geographic races of the gray wolf, was listed as endangered and became legally protected in 1974. The historical and current distribution of the wolf includes the IPGA. Unverified sightings have occurred on the area for several years, and verified sightings have been made adjacent to the IPGA. The area is at the edge of the wolf's present distribution, and thus is used occasionally (Dennis Flath, Team leader, Northern Rocky Mountain Wolf Recovery Team, 1978).

The American peregrine falcon (**Falco peregrinus anatum**), an endangered species, is known to use the IPGA, but none nested on the area in 1975 or 1977. Historic eyries on the area are not active. One peregrine sighted in 1977 in the northern section of the IPGA along the Continental Divide was probably migrating, since the sighting coincided with the migration period. No other sightings have been reported.

The Northern bald eagle (**Haliaeetus leucocephalus**), recently listed as an endangered species, is an uncommon breeder on the IPGA. One nest was discovered within the IPGA in 1977, and another to the west along Henrys Lake. Five young fledged from the two nests. There are two productive nests north of the IPGA along Hebgen Lake. Bald eagles feed extensively on lakes and reservoirs in the IPGA in summer, and some birds winter on the area. Eagles are scattered throughout the area in summer. Targhee and Gallatin National Forests are presently identifying essential habitat for the bald eagle.

The grizzly bear (**Ursus arctos horribilis**), a threatened species, occurs throughout the IPGA, except the extreme western section. Bears on the area are part of the Yellowstone population, which has been studied since 1973 by an Interagency Grizzly Bear Study Team of research biologists from the National Park Service, Fish and Wildlife Service, Forest Service, and the States of Wyoming, Montana, and Idaho.

Approximately 135,000 acres (25%) of the IPGA have been designated essential grizzly bear habitat by the Forest Service and recommended as critical habitat (Map 11). Pending formal determination of critical habitat, essential habitat areas will be treated as critical habitat and protected from adverse modification or destruction.

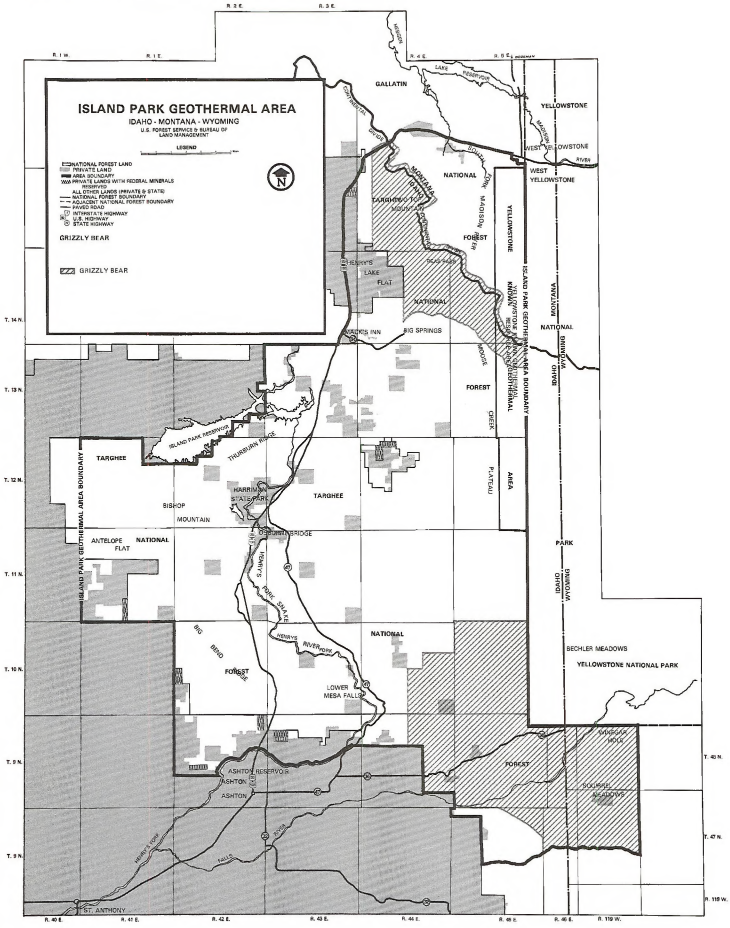
Delineation of essential grizzly bear habitat on the IPGA relied heavily upon past sightings-areas where bears have been regularly observed. All of the IPGA is historical grizzly habitat, but bears are usually seen in sections adjacent to Yellowstone National Park where human-bear conflicts are minimal.

On the IPGA some habitat appears more valuable to grizzlies than others, particularly those lands adjacent to Yellowstone National Park. The two designated portions (Reas Pass in the north, Winegar Hole in the south) were originally chosen because of the numerous sightings within them. The Interagency Grizzly Bear Study Team has confirmed that these areas contain habitat highly desired by bears. The plateau between these areas lacks many habitat features and is accordingly less desirable.

Research is being conducted on the Targhee National Forest to determine the quality of grizzly habitat. Results are not yet available, but on the IPGA some conclusions can be made.

The Reas Pass and Winegar Hole areas have highly productive forest understories, open wet meadows, bogs, swamps and potholes. Both contain extensive downed timber which supports heavily used food sources (fungi, rodents, insects). In wet areas, **Potamogeton** sp., an emergent aquatic plant, is used heavily. Yampa (**Perideridia gairdneri**) abundant throughout both areas, is an important food. Tall huckleberry habitat types (AF/Vagl, DF/Vagl) in Winegar Hole supports some of the most productive rodent populations on the Forest. Rodents, particularly pocket gophers (**Thomomys talpoides**), are an important grizzly food. Large numbers of rodents are present in both the Reas Pass and Winegar Hole areas with highest densities in wetter areas. Patterns of habitat use on the IPGA have yet to be identified, possibly due to changes in behavior and movement patterns from year to year. One den site has been located on the IPGA, on the Gallatin National Forest.

11. GRIZZLY BEAR ESSENTIAL HABITAT



As previously stated, the delineation of essential habitat was based primarily on recent sightings. However, additional data has been used to evaluate grizzly bear habitat. These data are from three primary sources:

1. Flight reports of the Interagency Team on radio-collared grizzlies:

   #14—A male collared in Winegar Hole in July 1976

   #23—A female collared in the Reas Pass region in September 1977

   #24—A female collared in the Reas Pass region in September 1977

   #25—A sow with two cubs collared in Gardiner, Montana which was shot at Island Park, Idaho in September 1977

   #30—A sow with two yearlings which ranged into Reas Pass in October 1977 (one yearling tagged near West Yellowstone)

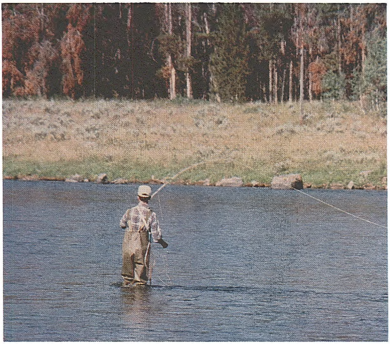
   #37—A cub collared in Squirrel Meadows, August 1978

2. Data from an on-going monitoring program on livestock allotments in the Reas Pass and Winegar Hole regions.

3. Procedures in **Criteria For Grizzly Bear Critical Habitat Identification**, U.S. Forest Service, Region 1, December 1975. A state of the art compendium.

FISHERIES

The major drainage system within the IPGA is the Henrys Fork (North Fork) of the Snake River. Relatively uniform water flows and temperatures, combined with high natural fertility and physical characteristics, provide for an outstanding cold-water fishery.



The sport fishery in Henrys Fork on the IPGA attracts fishermen from throughout the nation. With an annual use of nearly 95,000 angler days (valued at approximately 1.4 million dollars annually), and a catch of 175,000 salmonids (mostly trout) in 1973, this reach of Henrys Fork is possibly the most important stream in the State of Idaho.

Two reservoirs are influenced by streams flowing from the IPGA. The south fork of the Madison River, in the northeastern portion of the IPGA, supplies fish to Hebgen Lake, a significant fishery in Montana. Island Park Reservoir, within and adjacent to the IPGA, receives over 20,000 angler days use each year. Fish from Island Park Reservoir and Hebgen Lake rely heavily upon streams within the IPGA for spawning and rearing.

TABLE 19. SIGNIFICANT FISHERIES WITHIN THE ISLAND PARK GEOTHERMAL AREA

	Recorded fish species												Fishery[1] rating	Fish habitat[2] suitability
River or Stream	Wild rainbow trout	Hatchery rainbow trout	Cutthroat trout	Rainbow/Cutthroat hybrid	Brook trout	Brown trout	Mountain whitefish	Kokanee and Coho salmon	Suckers	Shiners	Dace	Sculpin		
Henrys Fork	X	X	X	X	X		X	X	X	X		X	4	very good
Fall River	X	X	X	X	X		X		X			X	3	good
Conant Creek	X	X	X		X		X		X	X	X	X	2	good
Squirrel Creek	X		X		X		X		X		X	X	2	fair
Boone Creek					X								2	*good
Sand Creek	X				X								unrated	undetermined
Rattlesnake Creek	X				X								1	poor
Willow Creek	X				X								1	*fair
Warm River	X		X	X	X		X		X			X	3	*good
Robinson Creek	X		X		X	X	X		X	X	X	X	3	*good
Rock Creek	X				X				X		X	X	2	good
Snow Creek			X		X								2	*good
Partridge Creek	X		X										2	poor
Thurburn Creek	X				X								unrated	very good
Split Creek					X								1	poor
Buffalo River	X	X			X							X	3	*very good
Moose Creek	X				X			X					4	*good
Big Springs	X		X	X									unrated	good
Henrys Lake Outlet	X		X	X	X		X	X		X	X	X	4	very good
Meadow Creek					X								1	fair
Jesse Creek					X								1	fair
Twin Creek			X		X							X	2	fair
Targhee Creek			X		X							X	2	fair
So. Fork Madison River	X					X							4	*good

[1] Fishery ratings were determined as follows:

1 = The aquatic environment produces some fish but stream or fishery conditions do not attract fishermen; or there is opportunity for this stream to contribute a low number of fish to offsite streams.

2 = The aquatic environment produces fair fish populations receiving some fishing pressure; or the stream contributes low numbers of fish to offsite streams used by fishermen.

3 = The aquatic environment produces good fish populations which are sought after by anglers; or the stream contributes moderate numbers of fish to offsite streams receiving moderate recreation demand.

4 = The aquatic environment produces excellent fish populations which are highly sought; or the stream may contribute high numbers of fish to offsite streams receiving high recreation use.

[2] Fish habitat suitability was assessed by evaluating the following parameters: pool habitat, streamside cover, food abundance, channel stability, and spawning habitat (* = significant spawning habitat)

Only a few aquatic environments and their fisheries have been studied in detail, and a full evaluation of these habitats is not possible. However, available data permit a general evaluation of fisheries and significant streams within the IPGA.

In 1977, the Fish and Wildlife Service's Office of Ecological Services evaluated the streams on the IPGA in a qualitative manner. Their report, on file with the Targhee National Forest, contains:

(1) a description of each stream's general physical characteristics

(2) fishery data collected by the State Fish and Game Departments

(3) individual data for each distinct stream reach

(4) available water quality data from state and federal agencies

(5) maps displaying trout habitat suitabilities, channel stability ratings, and significant stream features.

Table 19 is a summary of significant fisheries within the IPGA.

In 1976, the composition of game fish harvested on the Henrys Fork was 53% wild rainbow, 19% hatchery rainbow, 16% brook trout, 5% rainbow/cutthroat hybrids, less than 1% cutthroat trout, less than 0.1% kokanee salmon, and 7% mountain whitefish. Total angler hours have increased four percent in the last three to four years, while trout harvest has decreased 11 percent due to more restrictive regulations and fish population fluctuations.

Henrys Fork is stocked in a few locations with catchable-size rainbow trout which make up 11-20 percent of the fish harvest. However, most of Henrys Fork is currently managed as a "wild" trout stream.

Most of the tributary rivers and streams of Henrys Fork provide habitat for smaller resident fisheries. Many contain significant spawning and rearing habitat for native cutthroat trout. Kokanee salmon also depend on some of these streams (table 19). The Fall River, Warm River, and Robinson Creek are planted regularly by the Idaho Fish and Game Department. Many smaller streams with low fishery and habitat ratings are very important because they influence water quality of streams with higher ratings.

The South Fork of the Madison River in the northeastern part of the IPGA is one of two primary spawning grounds for fish from Hebgen Lake. The Montana Fish and Game Department plans to reestablish the wild trout fishery, and the tributaries are most important in achieving this goal. Any increase in nutrients or toxic substances could jeopardize this effort.

There are no significant lake fisheries within the IPGA other than Island Park Reservoir. Most of the lakes and potholes in the southeastern portion are small, shallow, and stagnant. Some do contain fish, but most are non-game species. Those that do have game fish receive very little use. However, there is potential to improve these aquatic habitats and increase the recreational opportunity. Two fish-holding reservoirs are in Harriman State Park: Golden and Silver lake. Golden Lake has an excellent population of brook and rainbow trout, while Silver Lake due to too many chubs is in need of rehabilitation. Ashton Reservoir, which extends onto the southwestern portion of the IPGA, receives flow from many streams in the Big Bend Ridge area, but production of invertebrate fauna and fish is poor.

Henrys Lake and Island Park Reservoir both receive heavy fishing pressure. The Island Park Dam is scheduled for repair in 1979 and the reservoir will be drawn down in mid-1979. The Idaho Fish and Game Department plans to chemically treat the reservoir during this drawdown.

There are no known federal or state listed threatened or endangered fish species, or any species of special concern on the IPGA.

In 1977 the Geothermal Environmental Statement Team decided that information on macroinvertebrates would make baseline data available for the geothermal environmental statement and also assist land managers on public lands.

Information on aquatic macroinvertebrates can be used to:

- Detect stress conditions and determine if they are due to natural causes or management practices
- Identify specific problems in a stream by determining the species present
- Help evaluate a stream's fishery potential.

Twelve major rivers and streams within IPGA were analyzed. When two stations were established on a stream, the upper one was located near the source or the point where the watercourse entered the IPGA, and the lower one was located where the stream exited the area. This provided data to make a control/treatment analysis of the streams.

The Geothermal Team established sampling stations and collected monthly samples during 1977. The samples were analyzed at the U.S. Forest Service's Aquatic Ecosystems Lab in Provo, Utah. Table 20 presents a summary of the results. The entire report is on file with the Targhee National Forest.

TABLE 20. SUMMARY OF AQUATIC MACROINVERTEBRATE SAMPLING ON THE ISLAND PARK GEOTHERMAL AREA.

				Environmental Influences[3]	
River or stream	Diversity[1, 3]	Biomass[2, 3]	Water quality[3]	sedimentation	organic enrichment
Henrys Fork					
Upper	Good	Good	Fair		X
Lower	Good	Excellent	Good		
Fall River					
Upper	Good	Fair	Good		X
Lower	Fair to Good	Poor to Excellent	Good		X
Conant Creek	Good	Excellent	Good		X
Warm River					
Upper	Good	Excellent	Excellent		X
Lower	Fair to Good	Good to Excellent	Good		X
Robinson Creek					
Upper	Good	Good	Good		X
Lower	Good	Good to Excellent	Good		X
Rock Creek	Good	Good	Good		
Thurburn Creek (Middle Fork)	Fair	Excellent	Good	X	
Split Creek	Good	Fair	Good	X	X
Buffalo River	Good	Good to Excellent	Fair	X	
Moose Creek					
Upper	Good	Fair to Good	Good	X	
Lower	Good	Poor	Good	X	
Big Springs	Fair to Good	Good to Excellent	Excellent	X	
Madison River (South Fork)					
Upper	Fair to Good	Good	Excellent		X
Lower	Good to Excellent	Good to Excellent	Good		X

[1] Diversity—An index which combines the number of different organisms and their relative abundance.
Excellent = The community is well balanced and in excellent condition relative to physical and chemical conditions.
Good = Habitat or water quality is short of excellent.
Fair = Macroinvertebrates are waving a red flag indicating degeneration of the ecosystem.

[2] Biomass—The dry weight of the macroinvertebrates.

[3] The scales rate each study stream with a stream having ideal habitat and water chemistry for optimal productivity. An X under environmental influences indicates sedimentation and/or organic enrichment is above what is expected in the ideal stream.

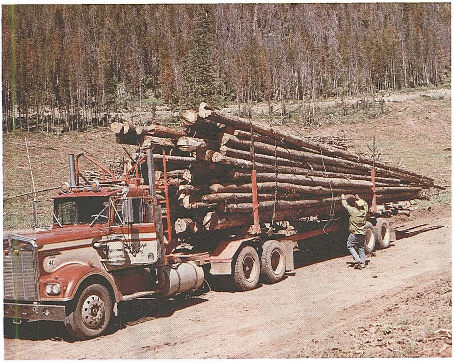
TIMBER

Timber resources are an important economic asset to the Upper Snake River Valley. The IPGA provides most of the timber for mills in Fremont County and some for other mills in Idaho, Montana and Wyoming.

Mountain pine beetle attacks have greatly impacted the timber management program within the lodgepole pine type. Many areas examined in 1976 contained nearly 70% dead trees, and some 80%. This dead material has resulted in development of other timber markets. An estimated 250-300 million board feet of lodgepole pine has been lost annually from 1976-1978 in the IPGA. Future sales of deadwood could be greater than 75 million board feet per year. Another 30-40 million board feet per year is removed by people with free use firewood permits.

The Moose Creek Plateau timber sale in the IPGA, comprising 318 million board feet, is the largest timber sale outside Alaska. Mountain pine beetle mortality has considerably reduced the available sale volume. Additional reductions may occur before the end of the timber sale contract period. Presently, the final harvest volume is expected to be about 200 million board feet from the 100 square mile sale area. Insect mortality and highly defective trees (rot, crook, etc.) have caused timber in some areas to be classed as unsalable. The current estimate of the area to be harvested is about 25,000 acres.

Timber from the IPGA provides a diversity of forest products. Fence posts, corral poles, house logs, cellar timbers and mineprops, in addition to stud log material, account for a significant portion of the sale volume. Indications are that demand for these products will continue to increase. Timber productivity estimates are presented in Table 21. Timber types are shown on Map 12.



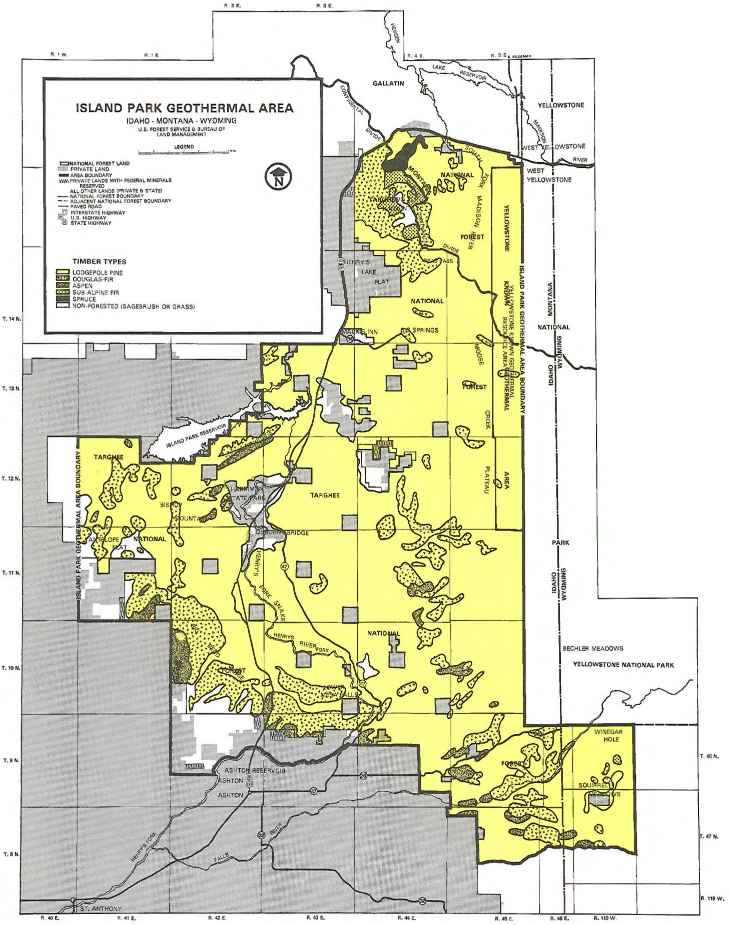
The IPGA supplies the majority of timber for mills in the adjacent area.

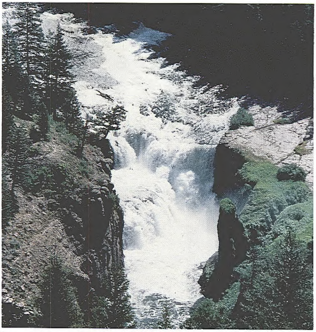
TABLE 21. AVERAGE GROWTH OF TIMBER IN THE ISLAND PARK GEOTHERMAL AREA

Timber Type	Cubic Feet Increase/Acre/Year
Lodgepole pine	40
Douglas-fir	60
Alpine fir/spruce	69
Aspen	23

Note: One 2 x 4 eight feet long contains approximately 0.4 cubic feet.

12. TIMBER TYPES





Grandview offers a picturesque view of Lower Mesa Falls and is in the heart of the IPGA.

VISUALS

The landscape character of the IPGA is varied. The quality and sensitivity depend on diversity of landforms, rock formations, vegetation, color, water features, number of viewers and distance from which the characteristics are viewed. Table 22 illustrates some of the visual characteristics.

Visual resource management goals have been established for the Island Park Geothermal Area. These were the result of a process which considers landscape variety and public concern for scenic quality (Sensitivity levels).

TABLE 22. VISUAL CHARACTER OF LANDTYPES IN THE ISLAND PARK GEOTHERMAL AREA

LANDTYPE	VISUAL CHARACTER	LOCATION	GENERAL QUALITY/SENSITIVITY
Mountainous	Much relief, rocky slopes sharp-exposed ridges, steep slopes, dominating landform rockform features	Continental Divide- N.E. portion (Mt. Two Top) Bishop Mtn. - High Point - West side of Big Bend Ridge (Rim of Island Park Caldera)	High
Plateau	0-30% slopes with little variety	East Side of Area (Moose Creek Plateau)	Low
Basin Lands-Flat	Little variety in vegetation patterns types, color or texture	Central Portion - within Island Park Caldera	Low
Open Park-Like	High degree of vegetation patterns and diversity	North portion E. of Henrys Lake and Central portion around Harriman State Park and widely scattered meadows	High
Mountain Slopelands (Forested)	Moderate slopes, common vegetation patterns - some diversity	Widely distributed, dominant landscape in S.E. portion	Medium
Aquatic or Water Associated	Large size, unique features, great diversity of flow, meandering shoreline patterns, etc.	Central and Eastern portions, widely distributed. (Streams & Lakes)	High
Canyons	Landform and rockform diversity, steep slopes	Primarily in the Southern portion	High

Five quality objectives describe different degrees of acceptable landscape change measured in terms of visual contrast with the surrounding natural landscape. These quality objectives are shown on map 13. Included with each quality objective is a time frame for reduction of visual impacts resulting from man's use of the land for timber harvest, construction and other purposes. The five objectives are:

1. *PRESERVATION*—This allows only ecological or natural changes and very low visual impact recreation facilities (examples: trails, log bridge).
2. *RETENTION*—Provides for management activities not visually evident (noticeable to most viewers) within the characteristic landscape. The objective should be accomplished either during operations or immediately after.
3. *PARTIAL RETENTION*—Management activities remain subordinate to the characteristic landscape (never dominate the view). Visual impact must be reduced as soon as possible after project completion or at most within the first year.
4. *MODIFICATION*—Activities may dominate, but must borrow form, color, and texture from the landscape. This objective should be accomplished in the first year or at a minimum should meet existing regional guidelines if they allow a long period.
5. *MAXIMUM MODIFICATION*—Management activities may dominate the characteristic landscape, but should appear as natural occurrences when viewed as background. Reduction of contrast should be accomplished within five years.

Table 23 compares the visual qualities of two locations within the Island Park area. This brief analysis contrasts the variability of the visual resource.

TABLE 23. COMPARISON OF VISUAL QUALITITES OF TWO LOCATIONS WITHIN THE ISLAND PARK GEOTHERMAL AREA

	BIG SPRINGS	MOST ANY POINT ON MOOSE CREEK PLATEAU ALONG FISH CREEK ROAD
Esthetic Concern of Viewer	High	Low
Number of Viewers	Several hundred per day	Less than 50 per day
Diversity of Landscape	Highly variable	Fairly uniform
Capacity to Absorb Alteration	Very low	Medium
Viewing Distance	Short (foreground)	Slightly variable (foreground & middleground)
Subject Focus of Viewer	Water, individual plants, fish	Road, groups of trees, regeneration areas
Visual Resource Management Goal (Quality objective)	Retention	Modification

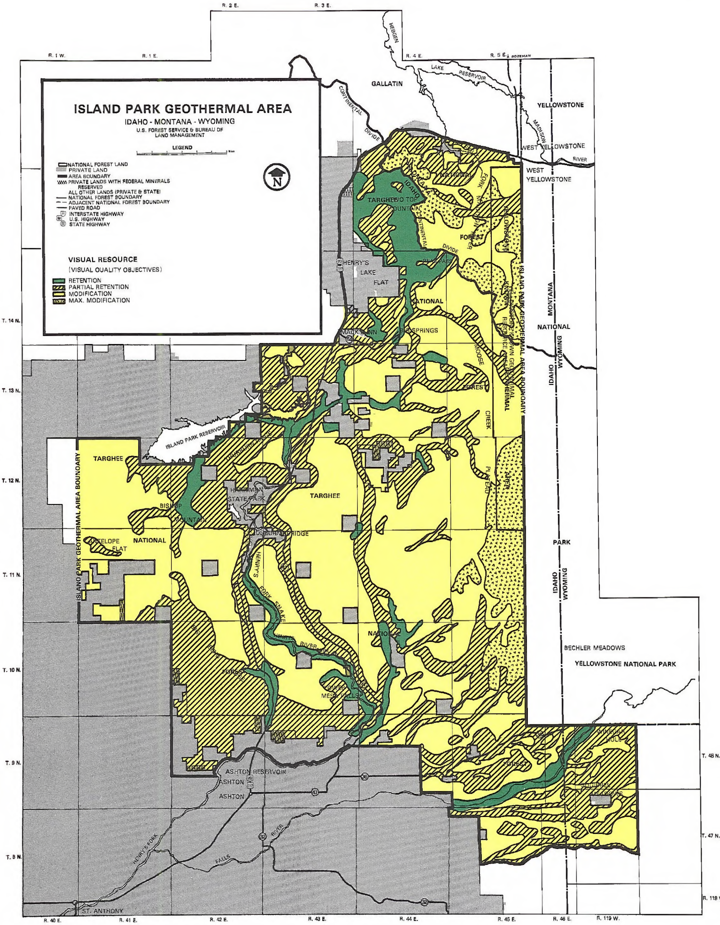
WILDERNESS

The Final Environmental Statement for Roadless Area Review and Evaluation (RARE II) includes 70 acres proposed for wilderness in the IPGA. Other roadless areas were identified earlier in RARE I and the Draft Environmental Statement for RARE II. They were either allocated to non-wilderness through the land management planning process and removed from the RARE II inventory, or they have been recommended for non-wilderness in the Final Environmental Statement for RARE II. Portions of two areas are in the latter category and include:

—Dry Canyon 01-550, Gallatin National Forest, Montana

—West Slope of the Tetons (West) W4-610, Targhee National Forest, Wyoming

The 70 acres recommended for wilderness is in the West Slope of the Tetons (East) E4-610, Targhee National Forest, Wyoming.


ISLAND PARK GEOTHERMAL AREA
IDAHO - MONTANA - WYOMING
U.S. FOREST SERVICE & BUREAU OF LAND MANAGEMENT
LEGEND
NATIONAL FOREST LAND
PRIVATE LAND
AREA BOUNDARY
PRIVATE LANDS WITH FEDERAL MINERALS RESERVED
ALL OTHER LANDS (PRIVATE & STATE)
NATIONAL FOREST BOUNDARY
ADJACENT NATIONAL FOREST BOUNDARY
PAVED ROAD
INTERSTATE HIGHWAY
U.S. HIGHWAY
STATE HIGHWAY
VISUAL RESOURCE
(VISUAL QUALITY OBJECTIVES)
RETENTION
PARTIAL RETENTION
MODIFICATION
MAX. MODIFICATION
GALLATIN
HEBGEN
LAKE
RESERVOIR
CONTINENTAL
DIVIDE
YELLOWSTONE
MADISON
WEST YELLOWSTONE
RIVER
WEST
YELLOWSTONE
TARGHEE
NATIONAL
FOREST
HENRY'S
LAKE
FLAT
MACK'S INN
MOOSE
CREEK
PLATEAU
ISLAND PARK GEOTHERMAL AREA BOUNDARY
MONTANA
NATIONAL
IDAHO
WYOMING
ISLAND PARK RESERVOIR
TARGHEE
TARGHEE
HARRIMAN
STATE PARK
BISHOP
MOUNTAIN
ANTELOPE
FLAT
NATIONAL
OSBORNE BRIDGE
HENRY'S
FORK
SNAKE
RIVER
PARK
IDAHO
WYOMING
BECHLER MEADOWS
YELLOWSTONE NATIONAL PARK
FOREST
MESA FALLS
WINEGAR
HOLE
FOREST
ASHTON RESERVOIR
ASHTON
ASHTON
HENRY'S FORK
FALLS
RIVER
ST. ANTHONY
R. 1 W.
R. 1 E.
R. 2 E.
R. 3 E.
R. 4 E.
R. 5 E.
T. 14 N.
T. 13 N.
T. 12 N.
T. 11 N.
T. 10 N.
T. 9 N.
T. 8 N.
T. 48 N.
T. 47 N.
R. 118 W.
R. 40 E.
R. 41 E.
R. 42 E.
R. 43 E.
R. 44 E.
R. 45 E.
R. 46 E.
R. 119 W.

Data and evaluations for each designated area are contained in the following documents on file with the Targhee National Forest:

- U.S. Department of Agriculture, Forest Service, 1978.
  Draft Environmental Statement—Roadless Area Review and Evaluation (RARE II), 78-04.
  Final Environmental Statement—Roadless Area Review and Evaluation (RARE II), 78-04.
- Supplements to DES on RARE II for States of Idaho, Montana, and Wyoming.
- Land Management Plan, Targhee National Forest, Island Park Planning Unit, and accompanying Final Environmental Statement.
- Land Use Plan, Targhee National Forest, West Slope of the Tetons Planning Unit.

SOUND

Qualitative and quantitative evaluation of sound levels, sound quality, or sources of noise (unwanted sound) has not been made on the IPGA. Without a thorough study of background sound levels and noise problems, there can be no accurate assessment of the proposal's effects on the sound environment. However, a cursory description of sound levels and noise sources is in table 24. The Geothermal E.S. Team recorded sound levels on the IPGA using a hand-held sound meter on the A-weighted scale with slow response. Table 24 compares sound levels on the IPGA with levels from other sources and with the Geysers Geothermal Area. The IPGA has low overall ambient sound levels (less than 45 db (A)). Most of the sound was caused by wind, with higher levels associated with man's activities (highways, timber harvesting, recreation sites, etc.). Federal and state guidelines on noise exposure are presented in table 25.

TABLE 24. SOUND LEVEL COMPARISONS BETWEEN THE ISLAND PARK GEOTHERMAL AREA (IPGA), OTHER SOURCES OF NOISE, AND THE GEYSERS GEOTHERMAL AREA IN CALIFORNIA

	Source	Sound level (dB(A))[1]	Distance from source (feet)
IPGA	Forested habitat	less than 40	—
	Riparian habitat	40 - 45	—
	Open meadow	40 - 45	—
	Upper Mesa Falls	79	50
	U.S. Highway 20-191	63 - 78	50
	Timber cutting operation —falling	65	200
	—yarding & decking	50 - 55	200
	Chainsaw, snowmobile	75	50
	Campground	40 - 45	—
	Summer home area	less than 40	—
Other sources	Threshold of pain	120	—
	Jet aircraft takeoff	125	200
	Unmuffled diesel truck	100	50
	Street corner in Idaho Falls	70	—
	Residential area in St. Anthony at night	less than 40	—
	Conversation	60	3
	Loud motorcycle	95	50
Geysers Geothermal Area	Drilling operation (air)	126	25
	Drilling operation (air)	55	1500
	Muffled test well	100	25
	Muffled test well	65	1500
	Steam line vent	100	25
	Steam line vent	90	1500

[1] Sound levels were measured using the universal standard called the decibel, dB. The term dB(A) is the decibel value measured using the A weighting network of a standard sound level meter with slow response.

TABLE 25. FEDERAL AND STATE GUIDELINES ON OCCUPATIONAL NOISE EXPOSURE[1]

Environmental Protection Agency		
Effect	**Level (dB)[3]**	**Area**
Hearing loss	$L_{eq(24)} = 70$	All areas
Outdoor activity interference and annoyance	$L_{dn} = 55$	Outdoors in residential areas, farms, and other areas where people spend widely varying amounts of time, and other places in which quiet is a basis for use.
	$L_{eq(24)} = 55$	Outdoor areas where people spend limited amounts of time, such as school yards, playgrounds, etc.
Indoor activity interference and annoyance	$L_{dn} = 45$	Indoor residential areas.
	$L_{eq(24)} = 45$	Other outdoor areas with human activities such as schools, etc.

Montana and Wyoming permissible noise exposure levels[2]	
Duration per day (hours)	**Sound level (dB(A))**
8	90
6	92
4	95
3	97
2	100
1½	102
1	105
¾	107
½	110
¼	115—ceiling value: no exposure in excess of 115 dB(A).

[1] Sources: (a) Environmental Protection Agency, 1974. Information on levels of environmental noise requisite to protect public health and welfare with an adequate margin of safety. EPA, Washington, D.C. (b) State of Montana, Department of Health and Environmental Sciences, Helena, Montana. (c) State of Wyoming, Occupational Health and Safety, Cheyenne, Wyoming.

[2] The state of Idaho has no specific regulations, guidelines, or standards on noise exposure other than that motor vehicles be equipped with mufflers to prevent excessive or unusual noise.

[3] dB = decibles; $L_{eq(24)}$ represents sound energy averaged over a 24-hour period expressed in decibles; L_{dn} represents the L_{eq} with a 10 decible nighttime weighting.

TRANSPORTATION

The existing road system in the IPGA includes State highways, County roads and forest development roads. A study being made to classify the roads by use will identify roads needed for public access or for land management. Unnecessary roads will be eliminated. Map 14 shows the existing transportation system within the IPGA.

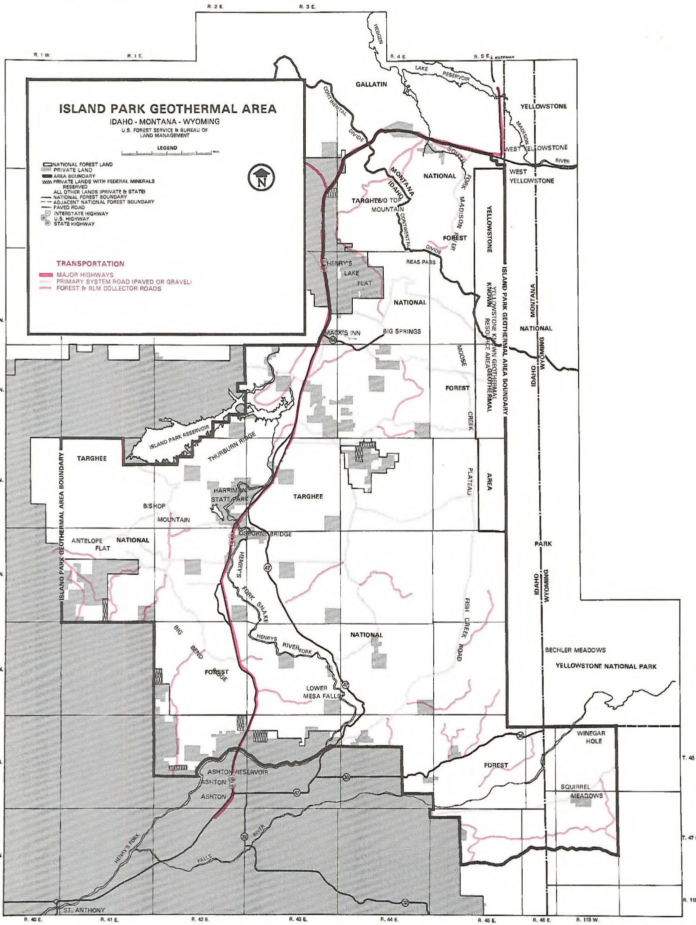
The need for a road system and its required level of maintenance change with demands upon resource uses. Presently, most road development relates to timber harvesting. Roads range from multipurpose graveled types to temporary roads obliterated following timber harvest. Current policy requires closure of unnecessary roads when their use will adversely affect resource protection, use or development, or when it is determined that the road is unsafe. A resource use often requires more roads than is desirable for resource protection. When re-entry is foreseen, the road is retained as a road closure, open on an intermittent basis.

Most road closures are an effort to lessen vehicle pressure on wildlife and their habitat, but some are needed for protection of watershed and roadway values, and others for construction, maintenance and safety.

On National Forest lands, road closure is posted at the Forest Supervisor and District Ranger offices and on the road. Vehicle passage through a closure can be gained by permit from the District Ranger for certain legitimate needs. When damage to the road is likely to occur a bond may be required.

No official designation of roads on BLM Public Lands has been done. Road closures, construction, etc. will be coordinated with National Forest management and made consistent with Regulations in 43 CFR part 6290 dealing with off-road-vehicles.

Several Forest Service trails established for resource protection are in the IPGA. Some are in poor condition due to lack of maintenance. Use of trails for hiking is an increasingly important part of the recreation program.


ISLAND PARK GEOTHERMAL AREA
IDAHO - MONTANA - WYOMING
U.S. FOREST SERVICE & BUREAU OF LAND MANAGEMENT
LEGEND
NATIONAL FOREST LAND
PRIVATE LAND
AREA BOUNDARY
PRIVATE LANDS WITH FEDERAL MINERALS RESERVED
ALL OTHER LANDS (PRIVATE & STATE)
NATIONAL FOREST BOUNDARY
ADJACENT NATIONAL FOREST BOUNDARY
PAVED ROAD
INTERSTATE HIGHWAY
U.S. HIGHWAY
STATE HIGHWAY
TRANSPORTATION
MAJOR HIGHWAYS
PRIMARY SYSTEM ROAD (PAVED OR GRAVEL)
FOREST & BLM COLLECTOR ROADS
GALLATIN
HEBGEN LAKE RESERVOIR
CONTINENTAL DIVIDE
YELLOWSTONE
MADISON
WEST YELLOWSTONE
RIVER
NATIONAL
SOUTH FORK MADISON RIVER
MONTANA
IDAHO
TARGHEE
TWO TOP MOUNTAIN
FOREST
REAS PASS
HENRY'S LAKE FLAT
MACK'S INN
BIG SPRINGS
MOOSE CREEK PLATEAU
ISLAND PARK GEOTHERMAL AREA BOUNDARY
YELLOWSTONE KNOWN GEOTHERMAL RESOURCE AREA
WYOMING
ISLAND PARK RESERVOIR
THURBURN RIDGE
HARRIMAN STATE PARK
BISHOP MOUNTAIN
ANTELOPE FLAT
OSBORNE BRIDGE
HENRY'S FORK SNAKE RIVER
BIG BEND RIDGE
LOWER MESA FALLS
FISH CREEK ROAD
PARK
BECHLER MEADOWS
YELLOWSTONE NATIONAL PARK
WINEGAR HOLE
SQUIRREL MEADOWS
ASHTON RESERVOIR
ASHTON
HENRY'S FORK
FALLS RIVER
ST. ANTHONY
R. 1 W.
R. 1 E.
R. 2 E.
R. 3 E.
R. 4 E.
R. 5 E.
R. 40 E.
R. 41 E.
R. 42 E.
R. 43 E.
R. 44 E.
R. 45 E.
R. 46 E.
R. 119 W.
R. 118 W.
T. 14 N.
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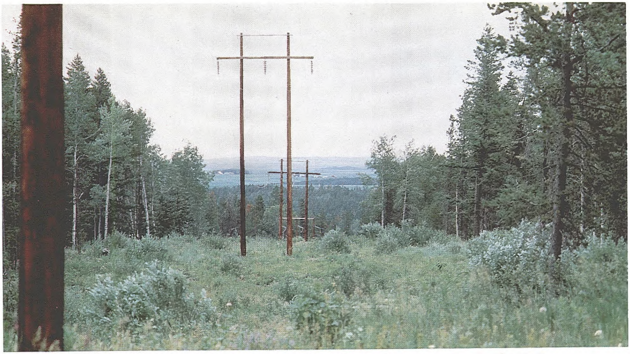


A 115 Kilovolt transmission line extends from the southern boundary to Mack's Inn.

UTILITIES

Two transmission lines transect the IPGA. Both are administered by Fall River Rural Electric Cooperative, Inc. of Ashton, Idaho. The 44 KV line constructed in 1949 runs from Ashton Reservoir north to West Yellowstone, Montana. The 115 KV line constructed in 1971 runs from Drummond, Idaho north to Mack's Inn, located on U.S. 191/20. Map 15 shows the transmission lines and the subdivisions they service within the Idaho portion of the IPGA.

Electricity from the two transmission lines is used primarily for residential service in Island Park and West Yellowstone. Commercial electrical uses are for resorts, shops, restaurants, service stations, and motels in and adjacent to the IPGA.

An extension of the 115 KV transmission line from Mack's Inn to West Yellowstone is being considered.

The Island Park Land Management Plan (1978) provides that utility corridors will be concentrated along existing use paths. These corridors are presently on a north-south axis through the area, but as regional demands increase and transmission grids become more complex, lines may be proposed to tie into services west of the IPGA.

SOCIO-ECONOMICS

A review of Fremont County, Idaho economic characteristics provides a good picture of the economy of the IPGA. As an estimate of the economy of the IPGA, Fremont County data somewhat overemphasizes agriculture and under-estimates the importance of the lumber industry.

Population

The 1975 Fremont County population of 9,616 is only 6% greater than in 1950, but 10% greater than the 1970 population, an annual growth rate of 2% for the years 1970-75. The county and Idaho are experiencing a population surge. The State's population grew more than 15.1% between 1970 and 1975. In 1970, Fremont County's population was:

23%	Rural farm
44%	Rural Non-farm
33%	Urban

The July 1976 population and employment forecast by the Idaho Department of Water Resources and Boise State University in Boise, Idaho, projects a 61% population increase in Fremont County by the year 2000, a 2% annual growth rate. Most of the IPGA has a fluctuating population due to the seasonal nature of the recreation industry.

Tables 26 and 27 present town population estimates and projected county population respectively.

15. TRANSMISSION LINES AND SUBDIVISIONS

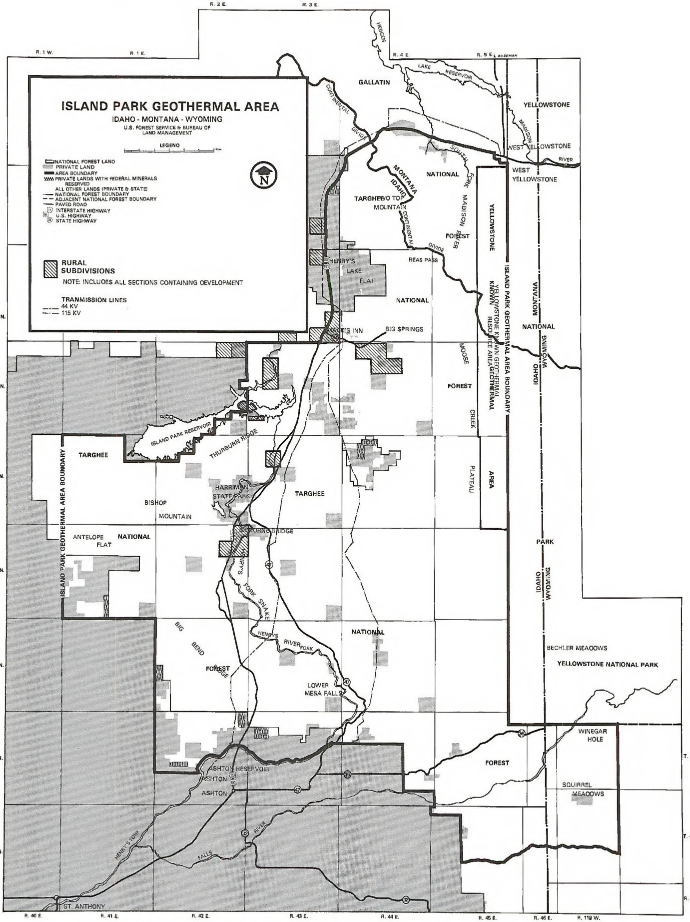
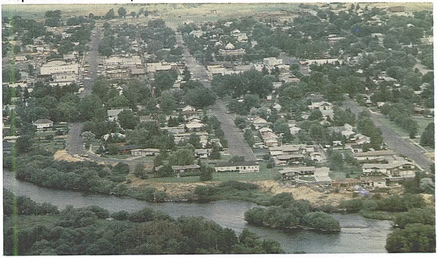


TABLE 26. TOWN POPULATIONS

	1970[1]	1975
St. Anthony	2,877	3,021[2]
Ashton	1,187	1,300
Island Park	371	152[3]
West Yellowstone	756	823[4]

[1] U.S. Census
[2] Town Clerk
[3] 1973 figure from County Profiles increased at 1970 to 1973 estimated annual growth rate of 1.95%
[4] Montana State Department of County Affairs



St. Anthony, the largest town in Fremont County, Idaho is approximately 18 miles from the IPGA.

TABLE 27. FREMONT COUNTY, IDAHO POPULATION PROJECTIONS

AGE GROUP	1970	1975	1980	1985	1990	1995	2000
0- 4	878	1056	1361	1549	1626	1694	1840
5- 9	928	905	1048	1398	1599	1626	1625
10-14	1076	961	898	1094	1458	1601	1549
15-19	1080	1107	952	942	1153	1458	1522
20-24	466	1088	1097	966	963	1148	1417
25-29	475	478	1077	1110	987	959	1107
30-34	435	485	472	1088	1126	981	921
35-39	420	444	478	486	1101	1117	942
40-44	488	429	435	493	507	1087	1065
45-49	430	491	417	441	507	498	1031
50-54	432	429	471	422	454	491	450
55-59	472	425	403	468	428	433	432
60-64	386	448	389	388	455	396	372
65-69	268	344	402	350	350	412	362
70-74	202	226	288	340	297	298	353
75-79	146	154	174	221	264	230	232
80-84	88	94	100	114	144	173	152
85+	40	54	61	65	74	91	111
TOTAL	8710	9618	10523	11938	13493	14693	15483

SOURCE: Idaho Dept. of Water Resources and Boise State Univ.

Employment

Agriculture, a primary industry in Fremont County, employed 969 people in 1972, with 171,000 acres devoted to irrigated or dry crop land. The livestock industry is significant with 37,500 head of cattle in the county in 1974.

Table 28 summarizes employment in Fremont County. The unemployment rate in Fremont County (mid 1978) is about 6.4%. Since West Yellowstone, Montana is a resort community with a constantly fluctuating population and seasonal unemployment, it is difficult to estimate an unemployment rate in the West Yellowstone area.

TABLE 28. FREMONT COUNTY, IDAHO
EMPLOYMENT FORECAST BY MAJOR INDUSTRY

MAJOR INDUSTRY	1972	1975	1980	1985	1990	1995	2000
AGRICULTURE	969	949	923	897	871	845	819
MANUFACTURING	210	270	315	359	404	448	493
CONSTRUCTION	50	55	59	63	70	77	83
TRANSPORTATION	107	127	146	165	184	204	223
TRADE	568	640	810	980	1150	1320	1490
FINANCE	18	17	16	16	16	15	15
FEDERAL CIVILIAN	160	156	147	137	128	119	109
STATE AND LOCAL	530	610	692	773	854	936	1017
SERVICES	250	284	284	284	284	284	284
OTHER NON-AG	836	787	909	1067	1289	1541	1757
TOTAL	3698	3895	4301	4741	5250	5789	6290

SOURCE: Idaho Department of Water Resources and Boise State Univ.

Income

The relative prosperity in the county and the area seems to be improving. In 1970 county per capita income was only 63.7% of the national per capita income but by 1974 it had risen to 87.2%. In Idaho per capita personal income as a percentage of national average income increased from 82% in 1972 to 91% in 1974; in Wyoming from 94% in 1972 to 99% in 1974; and in Montana 90% in 1972 to 91% in 1974. Tables 29 and 30 review per capita personal income for the years 1966 to 1974 for counties in Southeast Idaho, adjacent to and including the IPGA.

Table 30 shows per capita income in constant 1977 dollars. This shows the reduction in purchasing power of the dollar from 1966 to 1977. For example the per capita income in Bonneville County in 1966 was $2,738, but in terms of 1977 dollars, it was $5,113.

TABLE 29. PER CAPITA PERSONAL INCOME OF SOUTHEAST IDAHO BY COUNTY IN DOLLARS

COUNTY	1966	1968	1970	1972	1974
BONNEVILLE	2738	3031	3408	4106	5214
BUTTE	1919	2558	3313	3588	4395
CLARK	1811	2979	5446	3527	4207
CUSTER	1892	2150	2500	2882	3551
FREMONT	1988	2139	2525	3224	4752
JEFFERSON	1820	1765	2327	2785	3674
LEMHI	1832	2115	2578	3014	3428
MADISON	1904	1897	2008	2562	4031
TETON	1358	1639	2463	2606	4880

SOURCE: R.D. Payne, Recreation Home Development in Idaho: Five Case Studies, 1977.

TABLE 30. PER CAPITA PERSONAL INCOME OF SOUTHEAST IDAHO BY COUNTY (1977 DOLLARS)

COUNTY	1966	1968	1970	1972	1974
BONNEVILLE	5113	5280	5319	5948	6407
BUTTE	3583	4456	5170	5197	5401
CLARK	3382	5189	8499	5109	5170
CUSTER	3533	3745	3902	4175	4364
FREMONT	3712	3726	3941	4670	5839
JEFFERSON	3398	3074	3632	4034	4515
LEMHI	3421	3684	4023	4366	4212
MADISON	3555	3304	3133	3711	4953
TETON	2536	2855	3844	3775	5997

SOURCE: Consumer Price Index, Economic Report of the President, January 1978, (Indexed)

Housing

Ashton and St. Anthony have a very tight housing market. Public officials and Forest Service personnel indicate that even at the present slow rate of growth, it is difficult for newcomers to find housing. The following year by year building permits record from 1970 to 1975 illustrates this situation:

	1970	1971	1972	1973	1974	1975	1976	1977
ASHTON	3	2	4	2	6	4		5*
ST. ANTHONY	5	12	33	10	24	19	13	22

*Includes 1976 and 1977.

The 33 building permits issued in St. Anthony in 1972 reflect the population influx from the Teton Dam construction. This seems to indicate that supply is responsive to changes in demand. Ashton approved one new subdivision during 1977. In St. Anthony two new subdivisions have been accepted in the last year with 60 single family lots and 24 apartment units. The destruction and reconstruction resulting from the collapse of the Teton Dam seem to have caused the latest housing pinch and also increased construction of housing.

These towns can accommodate increased housing demand if it happens at a slow rate. There is no provision for the temporary housing or trailer parks.

West Yellowstone has the capacity to house all workers the geothermal development is likely to bring. In 1976 there were 506 residential units divided evenly among single family homes, mobile homes and apartments. In addition, there were 55 motels with 1,951 beds for which workers would be competing with the tourists. Construction workers, especially those who come without families and can share a rented apartment or motel, will be able to outbid the tourists because they will arrive earlier in the year and stay longer. However, the result is likely to be high cost housing for worker and tourist alike. At present all of West Yellowstone is commercially zoned. New residential development has to leapfrog to private lands several miles from town. The Island Park area in the middle of the IPGA contains 600 or more seasonal homes. While some are certainly income producing properties, most are not in the short term housing market.

Schools

Two school districts which would have to absorb the student load created by geothermal development in the IPGA are located in West Yellowstone, Montana, and Fremont County, Idaho. For the 1977 to 1978 school year, West Yellowstone schools budgeted for an enrollment of 242 students. The Fremont County District budgeted for 2,533 students. School officials generally felt optimistic about their ability to cope with growth.

The construction of Teton Dam in the early 1970's put 70 children into the Fremont School District and stimulated a building program and improvements that have left the district with the capability to add new students to existing capacity and to finance additional facilities.

The West Yellowstone schools have 36 less students than in 1972 due to the closing of the nearby stud mill in the Gallatin National Forest. Bonded indebtedness is only 11% of capacity.

Public Issues and Attitudes

In-depth interviews were conducted with eleven people to assist in assessing social impacts and public attitudes towards geothermal development. Included were two school superintendents, one electric utilities executive, one mayor, two Forest Service District Rangers, one local merchant, one town clerk, one farmer, one magistrate and one timber industry forester. Three live in West Yellowstone, the remainder in and around St. Anthony, Ashton, and Island Park.

Geothermal development is not now a public controversy. The people interviewed indicated that there has been little discussion of it pro or con within the community. When the Forest Service mailed out an information brochure on potential geothermal development with a mail back questionnaire attached, many went to people in the communities around the IPGA, but none of them responded. Those interviewed, however, did indicate that they felt the majority of the public would favor geothermal development. The general opinion was that geothermal development would boost the economy and provide a possible way to keep electric rates from rising.

A panel of five members knowledgeable of the people and resources within the IPGA participated in a work session to analyze social group attitudes. Four issues were identified and panel members estimated a response for each social group delineated. Table 31 is a summary of this evaluation.

Considerable sociological and economic data specific to geothermal development in the IPGA are on file in the Supervisor's Office, Targhee National Forest. Most of these data were generated for the report, "Island Park Geothermal Energy Development—Social and Economic Assessment," EDAW Inc., Fort Collins, Colorado.

TABLE 31. POSITIONS ESTIMATED TO BE TAKEN BY SOCIAL GROUP CATEGORIES ON FOUR BASE ISSUES*

Conflict Issues	Sawmills/ Planing Mills	Logging Contractors	Cattle Grazers	Sheep Grazers	Farmers	Food Processing/ Wholesaling	Realtors/ Bankers	Retail Sales/ Services	Dispersed Recreation/ Non-Motorized	Dispersed Recreation/ Motorized	Hunting	Water Based Recreation/Developed	Water Based Recreation/Undeveloped	Developed Land Based Recreation	Seasonal Residents (Within Study Area)	Year-Round Residents Within Study Area)	Residents (Adjacent to Study Area)
Designation of Critical Grizzly Bear Habitat in the National Forest	–	–	–	–	–	0	–	0	+	–	–	0	+	–	0	–	–
Designation of Additional Roadless Areas in the National Forest	–	–	–	–	–	0	–	–	+	–	–	–	+	–	–	–	–
Residential and Commercial Development in Island Park Area	–	–	–	–	0	0	+	+	–	–	–	+	–	+	–	–	–
Increased Public Access to Harriman State Park	+	+	+	+	+	0	+	+	–	+	0	+	–	+	+	+	+

* (+) = for; (–) = against; (0) = neutral
Values represent medians for the Delphi panel estimates.

III. EVALUATION CRITERIA

Criteria are standards on which a judgement or decision may be based. Our criteria deal with goals, objectives, and tests of feasibility used to evaluate alternatives for geothermal leasing.

A plan developed at the beginning of the Island Park Geothermal Environmental Statement process defined goals and objectives for the statement. Criteria identified for the development of viable alternatives for geothermal leasing stated that alternatives should:

- Meet legal requirements
- Be acceptable to the majority of interested agencies, organizations, and individuals
- Be consistent with federal land management policies
- Be economically and technologically feasible

Alternatives developed are discussed in Section IV. This draft environmental statement does not identify a preferred alternative. The tentative decision criteria to be used in selecting a favored alternative are :

1. The Geothermal Steam Act of 1970 (which authorizes the Secretary of the Interior to allocate geothermal steam and associated geothermal resources on Federal lands) will be used to evaluate leasing. It makes these lands available for geothermal leasing and development, but only under terms and conditions that insure use of the lands for the purposes for which they were withdrawn or acquired.
2. A high degree of public acceptance of a proposal is desired. Comments received before and after this draft environmental statement will be considered in making this evaluation.
3. Effects of the proposal on landowners and individuals adjacent to the IPGA will be considered.
4. Forest Service and BLM resource management objectives will be major considerations of preferred alternative development.

   Forest Service

   Objectives are developed through implementation of the Resources Planning Act (RPA). The objective applicable to the above criteria is: "develop and demonstrate the use of technologies necessary to anticipate and ameliorate major adverse effects of fossil fuel and mineral development on the environment, surface resources, and people by 1985."

   Bureau of Land Management

   Objectives are developed in response to the Mining and Minerals Policy Act of 1970. The objective applicable to the above criteria is: make energy minerals available for use on a managed and controlled basis, consistent with national energy and related demands.

The decision criteria will be finalized after review of this document has been completed and the public has commented. As a result of this review and subsequent comments, new or modified decision criteria may be developed.

IV. ALTERNATIVES CONSIDERED

Alternatives developed to compare the effects of geothermal leasing and development in the IPGA identify several options for leasing and are consistent with existing laws and federal land management policies. Obviously, many other alternatives could be developed, including a mixture or perhaps different considerations from those presented here. However, most concerns and viewpoints are incorporated in the range of alternatives presented.

Table 32 shows the distribution of acres in the IPGA for each alternative. Figure 7 graphically shows the allocation of land by percentages for each alternative.

TABLE 32. DISTRIBUTION OF ACRES IN THE ISLAND PARK GEOTHERMAL AREA BY ALTERNATIVE

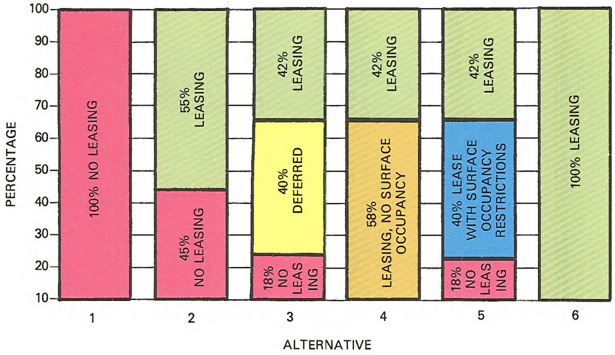
	Alternative					
	1	2	3	4	5	6
Leasing	0	268,418	207,120	207,120	207,120	488,031
No Leasing	488,031	219,613	87,916	0	87,916	0
Deferred	0	0	192,995	0	0	0
Leasing with no surface occupancy	0	0	0	280,911	0	0
Leasing with surface occupancy restrictions	0	0	0	0	192,995	0
TOTALS	488,031	488,031	488,031	488,031	488,031	488,031

ALTERNATIVE 1

No leasing. This alternative is required under the Council on Environmental Quality's guidelines and represents the status quo. It places emphasis on other resources at the expense of geothermal leasing and development.

While geothermal development is unlikely under this alternative, publicly owned geothermal reserves could be depleted by extraction on adjacent private lands. In addition surface effects from adjacent private developments could negatively affect the IPGA. Such effects include subsidence, seismicity, air and noise pollution, and negative effects on wildlife habitat and visual quality. The development of private lands adjacent to non-developed public lands could result in a less efficient use of the geothermal resources of the general area.

FIGURE 7. PERCENTAGE OF LAND ALLOCATION BY ALTERNATIVE IN THE IPGA



ALTERNATIVE 2

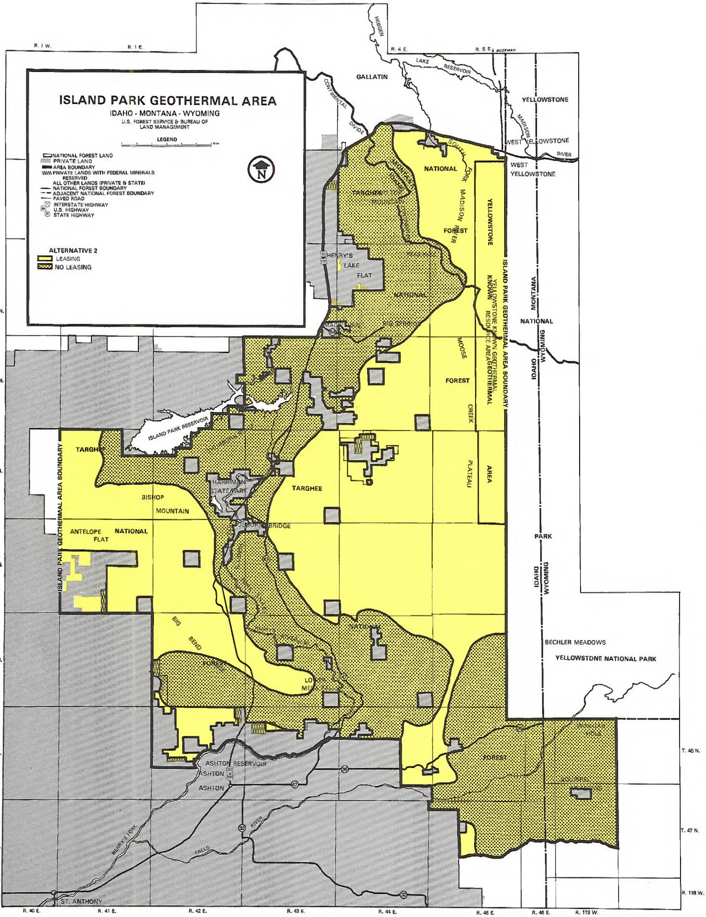
Lease only those lands identified as suitable by participants of the Geothermal Workshop held in Rexburg, Idaho on March 18, 1978.

Under this alternative, lands within the IPGA are divided as follows:

Leasing	268,418 acres
No Leasing	219,613 acres

The Geothermal Workshop was an all-day meeting allowing the public to indicate their concerns about geothermal leasing and development on the IPGA. Fifty-six people participated representing a variety of occupations.

The participants, divided into seven groups of five to seven people, were asked to collectively produce a map showing where leasing should or should not occur in the Island Park Geothermal Area. All but one group responded by either producing a map or making comments. Two groups made comments and five groups produced a map. Alternative 2 represents land more than half of the groups agreed should be available for leasing.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AREA BOUNDARY
PRIVATE LANDS WITH FEDERAL MINERALS RESERVED
ALL OTHER LANDS (PRIVATE & STATE)
NATIONAL FOREST BOUNDARY
ADJACENT NATIONAL FOREST BOUNDARY
PAVED ROAD
INTERSTATE HIGHWAY
U.S. HIGHWAY
STATE HIGHWAY
ALTERNATIVE 2
LEASING
NO LEASING
N
GALLATIN
HEBGEN
LAKE
RESERVOIR
CONTINENTAL DIVIDE
YELLOWSTONE
MADISON
WEST YELLOWSTONE
RIVER
NATIONAL
FOREST
SOUTH FORK MADISON RIVER
YELLOWSTONE
ISLAND PARK GEOTHERMAL AREA BOUNDARY
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T. 47 N.
R. 118 W.
R. 40 E.
R. 41 E.
R. 42 E.
R. 43 E.
R. 44 E.
R. 45 E.
R. 46 E.
R. 119 W.

Lands adjacent to Island Park Reservoir have high visual sensitivity.

Leasing	207,120 acres
Deferred at present time	192,995 acres
No Leasing	87,916 acres

Lands available for leasing include those where geothermal development would not likely cause significant adverse impacts to known surface resource values.

Lands deferred from leasing are those where geothermal resource development could have significant adverse impacts on surface resource values. These values include:

—highly visible timbered lands adjacent to Island Park Reservoir

—elk and deer migration routes

—moose winter range

—fish spawning streams

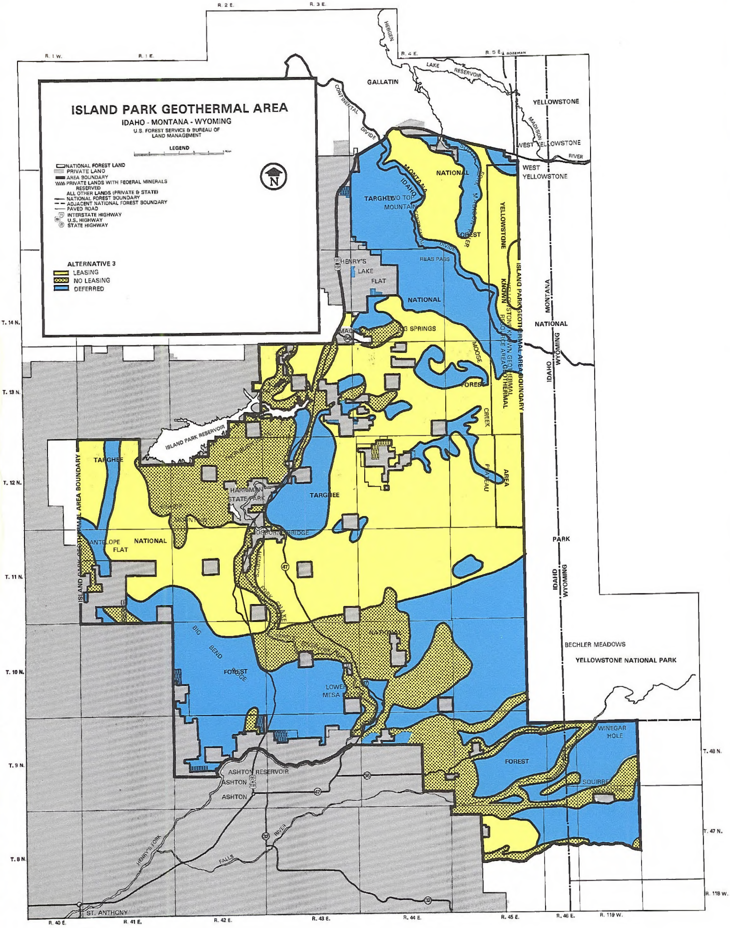
—sandhill crane and trumpeter swan feeding and nesting areas

—essential grizzly bear habitat

—areas of human development

The leasing decision on these lands will be made when more knowledge of the geothermal resource in the IPGA exists.

The no leasing category applies to all lands where geothermal development would create significant adverse modifications to high surface resource values.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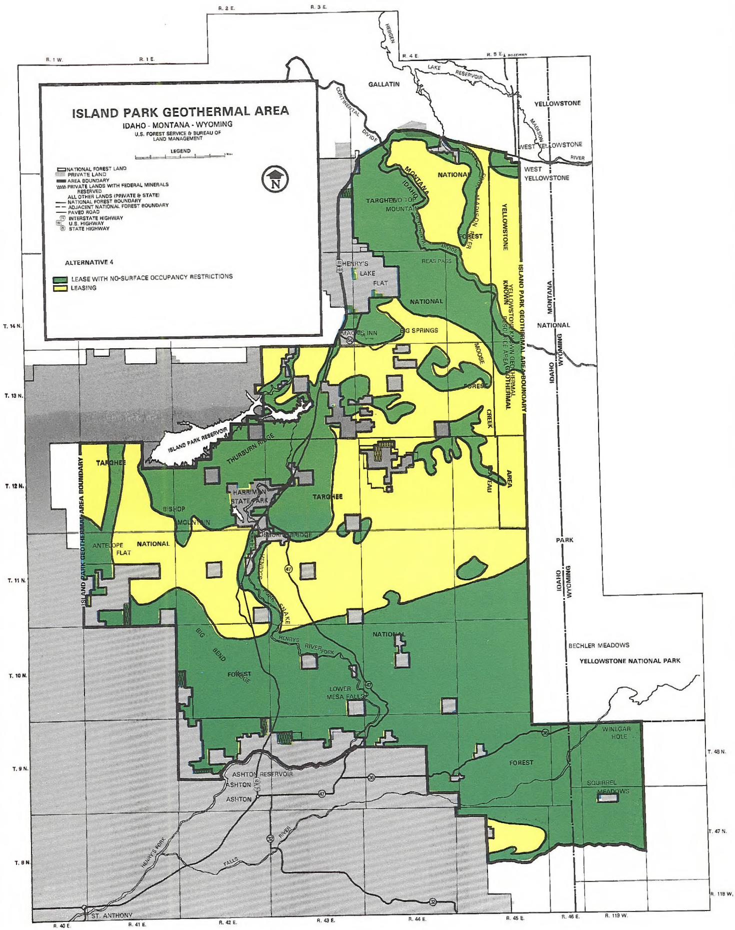
NATIONAL FOREST BOUNDARY
ADJACENT NATIONAL FOREST BOUNDARY
PAVED ROAD
INTERSTATE HIGHWAY
U.S. HIGHWAY
STATE HIGHWAY
ALTERNATIVE 3
LEASING
NO LEASING
DEFERRED
GALLATIN
YELLOWSTONE
WEST YELLOWSTONE
HENRY'S LAKE FLAT
NATIONAL
TARGHEE
FOREST
ISLAND PARK RESERVOIR
HARRIMAN STATE PARK
ANTELOPE FLAT
BIG BEND RIDGE
LOWER MESA
ASHTON RESERVOIR
ASHTON
ST. ANTHONY
BECHLER MEADOWS
YELLOWSTONE NATIONAL PARK
WINEGAR HOLE
ISLAND PARK GEOTHERMAL AREA BOUNDARY
MONTANA
IDAHO
WYOMING
PARK

A portion of the West Slope of the Tetons RARE II Area is in the IPGA.

Leasing	207,120 acres
Leasing with No Surface Occupancy	280,911 acres

Lands available for leasing include those where geothermal resource development would not likely cause significant adverse impacts to known surface resource values.

On lands with No Surface Occupancy restrictions, conditions unfavorable to geothermal resource development are known to exist. Well sites and building sites cannot be allowed where problems including terrain, unstable soils and slope hazards are known, or where human use activities will be impaired or disrupted. However, a lessee could develop the geothermal resource beneath the lands by directional drilling from adjacent lands.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ADJACENT NATIONAL FOREST BOUNDARY
PAVED ROAD
INTERSTATE HIGHWAY
U.S. HIGHWAY
STATE HIGHWAY
ALTERNATIVE 4
LEASE WITH NO-SURFACE OCCUPANCY RESTRICTIONS
LEASING
N
GALLATIN
HEBGEN
LAKE RESERVOIR
CONTINENTAL DIVIDE
YELLOWSTONE
WEST YELLOWSTONE
MADISON
RIVER
TARGHEE
TWO TOP MOUNTAIN
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MACKS INN
BIG SPRINGS
MOOSE CREEK PLATEAU
ISLAND PARK GEOTHERMAL AREA BOUNDARY
YELLOWSTONE KNOWN GEOTHERMAL RESOURCE AREA
WYOMING
ISLAND PARK RESERVOIR
THURBURN RIDGE
HARRIMAN STATE PARK
BISHOP MOUNTAIN
OSBORNE BRIDGE
ANTELOPE FLAT
HENRYS FORK SNAKE
HENRYS FORK RIVER
BIG BEND RIDGE
LOWER MESA FALLS
PARK
BECHLER MEADOWS
YELLOWSTONE NATIONAL PARK
WINEGAR HOLE
SQUIRREL MEADOWS
ASHTON RESERVOIR
ASHTON
HENRY'S FORK
FALLS RIVER
ST. ANTHONY
R. 1 W.
R. 1 E.
R. 2 E.
R. 3 E.
R. 4 E.
R. 5 E.
R. 40 E.
R. 41 E.
R. 42 E.
R. 43 E.
R. 44 E.
R. 45 E.
R. 46 E.
R. 119 W.
R. 118 W.
T. 14 N.
T. 13 N.
T. 12 N.
T. 11 N.
T. 10 N.
T. 9 N.
T. 8 N.
T. 48 N.
T. 47 N.

ALTERNATIVE 5

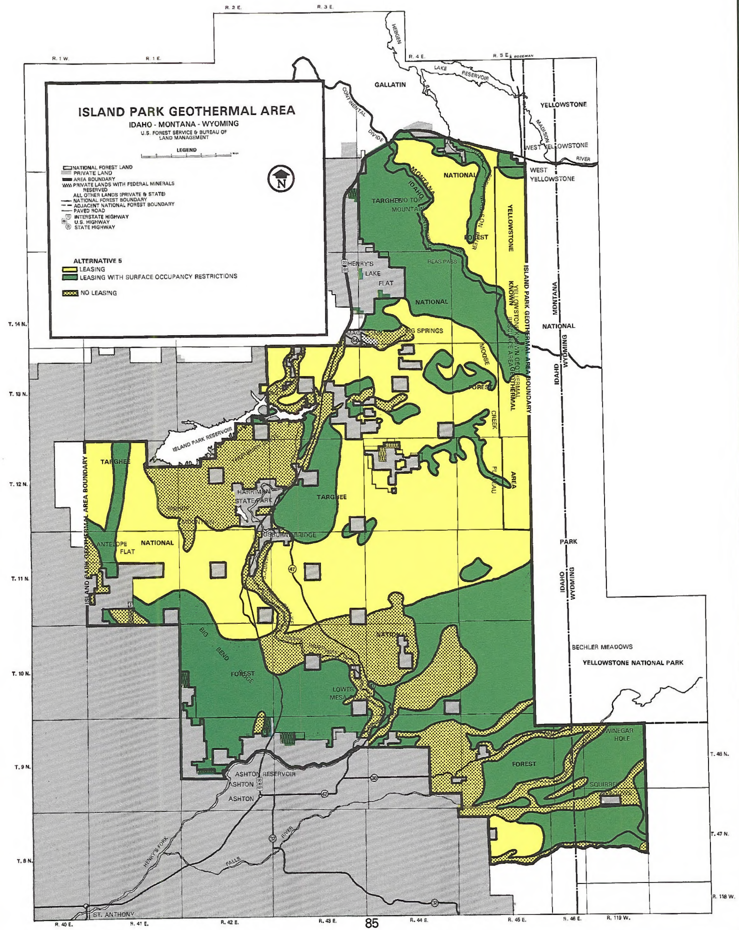
Robinson Creek originates in Yellowstone National Park and flows west through the IPGA to Warm River.

Leasing	207,120 acres
Leasing with surface occupancy restrictions	192,995 acres
No Leasing	87,916 acres

Lands available for leasing include those where geothermal resource development would not likely cause significant adverse impacts to known surface values.

Activities on lands with surface occupancy restrictions would be limited to non-disruptive surface exploration and drilling of gradient test holes. Existing roads would be used and test holes drilled by truck mounted or readily portable rigs only. Any additional proposals to develop a known or suspected geothermal resource would require site specific analysis under the NEPA process.

The no leasing category applies to all lands where geothermal development would create significant adverse modifications to high surface resource values.


ISLAND PARK GEOTHERMAL AREA
IDAHO - MONTANA - WYOMING
U.S. FOREST SERVICE & BUREAU OF LAND MANAGEMENT
LEGEND
NATIONAL FOREST LAND
PRIVATE LAND
AREA BOUNDARY
PRIVATE LANDS WITH FEDERAL MINERALS RESERVED
ALL OTHER LANDS (PRIVATE & STATE)
NATIONAL FOREST BOUNDARY
ADJACENT NATIONAL FOREST BOUNDARY
PAVED ROAD
INTERSTATE HIGHWAY
U.S. HIGHWAY
STATE HIGHWAY
ALTERNATIVE 5
LEASING
LEASING WITH SURFACE OCCUPANCY RESTRICTIONS
NO LEASING
GALLATIN
HEBGEN
LAKE
RESERVOIR
CONTINENTAL
DIVIDE
YELLOWSTONE
MADISON
WEST YELLOWSTONE
RIVER
NATIONAL
FOREST
TARGHEE
HENRY'S
LAKE
FLAT
BIG SPRINGS
MOOSE
CREEK
ISLAND PARK RESERVOIR
HARRIMAN STATE PARK
ISLAND PARK GEOTHERMAL AREA BOUNDARY
ANTELOPE
FLAT
BIG
BEND
LOWER
MESA
ASHTON RESERVOIR
ASHTON
HENRY'S FORK
FALLS
RIVER
ST. ANTHONY
MONTANA
IDAHO
WYOMING
PARK
BECHLER MEADOWS
YELLOWSTONE NATIONAL PARK
WINEGAR
HOLE
AREA
R. 1 W.
R. 1 E.
R. 2 E.
R. 3 E.
R. 4 E.
R. 5 E.
R. 40 E.
R. 41 E.
R. 42 E.
R. 43 E.
R. 44 E.
R. 45 E.
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T. 47 N.

ALTERNATIVE 6

Lease all Federal lands. This alternative assumes that geothermal leasing and development is the highest and best use for all land in the IPGA. Surface occupancy restrictions are not imposed and lessees would be controlled by standard leasing procedures contained in:

1. The Geothermal Steam Act of 1970.
2. Code of Federal Regulations.
3. Geothermal Resource Operational Orders.
4. Geothermal Resources Lease Form (3200-21) (see Appendix K).
5. Plan of Operation.

V. EFFECTS OF IMPLEMENTATION

Construction of geothermal facilities in the IPGA will introduce an industrial atmosphere into a National Forest that has historically been used largely for timber production, recreation, and other purposes generally requiring part-time human occupancy. Some of these lands will be occupied by industrial type installations that will remain for 25 to 100 years.

The type of facilities and land required depends on the use of the resource. An area varying from 800 to 2,000 acres is required for a 100 megawatt power plant similar to those at The Geysers. Space heating and other uses involving pipeline transmission of hot water, rather than generation and transmission of electricity, involve smaller land commitments. Within this total area, a maximum of approximately 180 acres is cleared to build pipelines, access roads, wells, power plants. etc.

Environmental impacts are dependent upon variables, including biological, geographic, geologic, physical, climatological, and demographic characteristics of the area to be developed. Other considerations are the physical and chemical character of the steam and/or associated fluids, the relationship between the geothermal reservoirs and fresh water aquifers, the extent and energy content of the geothermal resource, and the type of utilization facilities.

Geothermal energy development generally follows a sequence of exploration, test drilling, construction and development, and operation (where production is obtained). Abandonment begins upon failure to locate an economically usable resource in the test drilling phase or upon exhaustion of the reservoir.

Geothermal development would introduce industrialization into a forest setting.

In the broad perspective, favorable effects involve social and economic benefits; adverse effects involve conflicts with resource uses and the environment. In some instances categorizing an effect as favorable or adverse may be arbitrary due to the varying perspective of individuals.

Impacts were identified and evaluated for each phase of development by alternative. Since no geothermal resource has been discovered in the IPGA, site specific evaluation of effects can not be made. These evaluations will take place during the review of the leaseholder's "Plan of Operation". Table 33 lists the potential impacts of geothermal leasing and development in the Island Park Geothermal Area.

TABLE 33. POTENTIAL IMPACTS OF GEOTHERMAL LEASING AND DEVELOPMENT IN THE ISLAND PARK GEOTHERMAL AREA.

Resource	Phase	Activity	Change	Impact
Soil	Exploration	Explosives and seismic exploration	• Soil disturbance	—Localized soil compaction
		Drilling of shallow temperature gradient and observation holes	• Clearing of access	—Localized soil compaction
		Camping and housing of personnel	• Soil disturbance	—Localized soil compaction
	Test Drilling	Road, drill pad and sump construction	• Clearing, grading, cut and fill, excavation	—Soils: erosion, compaction, loss of attenuation properties in borrow areas
		Well blowout	• Uncontrolled effluent discharge	—Soil erosion and undermining of well pad area
	Construction and development	Power plant and facilities	• Clearing, grading, cut and fill, excavation	—Soil erosion, compaction
		Transmission and pipelines	• Clearing lanes	—Soil erosion, compaction
	Operation	Power plant operation and maintenance	• Release of gases and vapor	—Alteration of soil pH (from localized acid rain)
			• Erosion	—Permanent soil loss resulting from surface runoff
		Cooling tower operation and maintenance	• Blow-down discharge	—Alteration of soil pH
Water	Exploration	Explosives and seismic exploration	• Clearing for access	—Negligible increase in runoff which will be absorbed in non-disturbed areas.
			• Fracturing of bedrock	—Temporary alteration of groundwater flow with reduction in springflow and streamflows
		Drilling of shallow temperature and observation holes	• Clearing for access	—Negligible increase in runoff which will be absorbed in non-disturbed areas
			• Discharge of drilling wastes, mud, geothermal fluids, chemicals, etc.	—Water quality degradation (changes in pH, TDS, alkalinity, etc.)
			• Creation of route for groundwater movement and mixing	—Interaquifer transfer of water (e.g. water with high TDS moving into water with low TDS)
		Camping and housing of personnel	• Soil disturbance	—Negligible increase in runoff which will be absorbed in non-disturbed areas
	Test Drilling	Road, drill pad, and sump construction	• Clearing, grading, cut and fill, excavation	—Streams: bank alteration, diversions, siltation, chemical quality degradation (pH, TDS, color, organic agents), flow alteration from covering recharge areas, gradient change, etc.

Resource	Phase	Activity	Change	Impact
				—Groundwater: increased recharge and infiltration in borrow pits —Groundwater: loss of recharge in compacted areas
			• Possible discharge of drilling wastes, mud, geothermal fluids, etc.	—Streams: Direct entry into streams or leaching of noxious chemicals through soil to streams (increase in pH, Na, TDS, alkalinity) —Groundwater: Contamination of shallow groundwater aquifers (same chemical changes)
		Equipment maintenance	• Discharge of detergents, compounds (oil, gas, etc.)	—Pollution of surfce and groundwater
		Drilling and production testing	• Release of gases, vapors and toxic liquids	Water pollution same as above: —Streams: direct entry... —Groundwater: contamination...
		Well blowout	• Uncontrolled effluent discharge	Water pollution same as above: —Streams: direct entry... —Groundwater: contamination... —Chemical changes in water from increased dissolving power of warm and hot effluents (increases TDS, and many chemical constituents)
	Construction and development	Power plant and facilities	• Clearing and grading, cut and fill, excavation	Similar to test drilling but more intense: —Loss of groundwater recharge areas
			• Increased human presence	—Need for increased amounts of potable water (more wells, increased water treatment) —Reduction in the reserve of high quality groundwater —Increased sewage causing water quality degradation from septic systems
		Dewatering for deep excavation	• Lowered water table	—Reduces flow to small streams and springs (chemical and dilutional changes) —Causes nearby domestic and commercial wells to dry up —Disposal of pumped water into surface water causing channel and bank alteration, or onto dry land causing flooding —Reduces fisheries habitat
		Transmission lines and pipeline	• Clearing lanes	Similar to test drilling: —Loss of groundwater recharge areas
			• Increased human presence	Same as above: —Need for increased... —Reduction in the reserve... —Increased sewage...

Resource	Phase	Activity	Change	Impact
		Well drilling for cooling or make-up water	• Alteration of groundwater systems	—Creates a consumptive loss of water for other uses Similar to dewatering: —Reduces flows to streams... —Causes nearby wells... —Reduces instream fishery habitat
		Surface water impoundment or diversion for make-up or cooling water	• Reduced flows to downstream and instream uses	—Changes water chemistry (increased TDS, pH, temperature, hardness, alkalinity) —Creates demand on groundwater as substitute source —Reduces fishery habitat —Reduces recreational values (floating, fishing, etc.)
		Drilling production wells	• Release of gases, vapors, and toxic liquids	Water pollution same as in test drilling —Streams: direct entry... —Groundwater: contamination...
		Well blowout	• Uncontrolled effluent discharge	Water pollution same as in test drilling —Streams: direct entry... —Groundwater: contamination... —Chemical changes in water...
	Operation	Powerplant operation and maintenance	• Fertilization of grounds around facility, and use of weed control toxins	—Pollution to groundwater from leaching of chemical residues
			• Release of thermal water	Similar to test drilling: —Chemical changes in water...
			• Erosion	—Increases stream turbidity
			• Increased human presence	Similar to construction and development but long term: —Need for increased... —Reduction in the reserve of... —Increased sewage...
		Cooling tower operation and maintenance	• Washing of cooling tower baffles; blowdown discharge	—Pollutants to surface and groundwater (Cl, TDS, other salts)
		Reinjection	• "Lubricates faults"	—Potential for activation of faults; upward leakage of reinjected water could cause slope failures (earthslide) and soil erosion
			• Alteration of surface and groundwater quantity and quality	—Changes water chemistry (TDS, pH, hardness) through accidental losses —Water losses from well into aquifer can cause raised water table, increased seepage into streams and springs, appearance of new springs

Resource	Phase	Activity	Change	Impact
Air	Exploration	ORV travel, explosives and seismic exploration	• Increased dust	—Short term increase in particulates
	Test Drilling	Drilling and Production testing	• Release of gases, vapors and toxic liquids	—Air quality degradation (H_2S, NO_x, NH_3, CH_4, SO_2) —Short term increased humidity (fog, icing)
		Well blowout	• Uncontrolled effluent discharge	Same as above: —Air quality degradation... —Short term increased humidity (fog, icing)
	Construction and Development	Drilling production wells	• Release of gases, vapors	Similar to test drilling —Air quality degradation (H_2S, NO_x, NH_3, CH_4, SO_2) —Short term increased humidity (fog, icing)
		Well blowout	• Uncontrolled effluent discharge	Air pollution same as above; —Air quality degradation... —Increased humidity (until well is closed)...
		Power plant, facilities, roads, transmission lines, pipelines	• Increased dust	Similar to exploration —Short term increase...
	Operation	Power plant operation and maintenance	• Release of gases and vapors	Similar to test drilling but long term: —Air pollution (H_2S, NO_x, etc.)... —Increased humidity (fog, icing)...
		Cooling tower operation and maintenance	• Blowdown discharge	Similar to release of gases and vapors above: —Air pollution (H_2S, NO_x, etc.)... —Increased humidity (fog, icing)...

Resource	Phase	Activity	Change	Impact
Vegetation	Exploration	ORV travel	• Vegetation crushing	—Slight if routes are not used permanently or frequently
		Explosives and seismic exploration	• Soil/vegetation destruction and/or modification	—Minimal if not repeated on same site (shallow crater) —Stream habitat alteration
			• Clearing access routes	—Limited vegetation disturbance if use is mainly along existing roads; no new roads built —Increases fire hazard
		Drilling of shallow gradient holes	• Clearing access routes	Same as above: —Limited vegetation... —Increased fire hazard (fuel)
			• Preparation of drilling area	—Vegetation disturbance usually slight, less than one acre
			• Discharge of drilling wastes, mud, geotermal fluids, chemicals, etc.	—Kills terrestrial and aquatic vegetation —Alters nutrient cycles —Alteration of groundwater quality and quantity will affect the diversity, productivity, and abundance of vegetation dependent on water table (riparian, marshes, potholes, etc.)
		Camping and housing of personnel	• Refuse accumulation	—Improper management of garbage will alter vegetation nutrient cycles and surface water quality
	Test Drilling	Road, drill pad, and sump construction	• Clearing, grading, cut and fill, excavation	—Slash accumulation will increase hazard (fuel) of fires —Soil/vegetation destruction and/or modification
			• Herbicidal control of unwanted vegetation	—Toxic (kills) to non-target vegetation —Alters nutrient cycles
			• Possible discharge of drilling wastes, mud, geothermal fluids, chemicals, etc.	Same as under exploration although on a larger scale
			• Erosion	—Destruction and/or modification of surface and aquatic vegetation —Impaired plant growth —Stream channel alteration with deterioration of riparian and stream habitat
			• Increased human presence	—Possible destruction of terrestrial and aquatic vegetation —Increases risk of man-caused fires
			• Improper disposal of garbage and other waste	—Modifies nutrient cycling in soil and vegetation
		Equipment maintenance	• Discharge of detergents, oil, gas, etc.	—Destroys terrestrial and aquatic vegetation
		Blooie (steam well vent) line operation	• Projection of foreign particles (rocks, dirt, etc.)	—Soil/vegetation destruction and/or modification
		Drilling and production testing	• Release of gases, vapors, and toxic liquids	—Alteration of terrestrial and aquatic ecosystems—direct mortality of vegetation, reduced productivity, impaired growth, etc.
		Well Blowout	• Uncontrolled effluent discharge	—Pollution of terrestrial and aquatic ecosystems—poisoning of plants, direct destruction, etc.

Resource	Phase	Activity	Change	Impact
		Abandonment of wells	• Dismantling and grading	—Minimal disturbance of adjacent habitat; most activity is on site
			• Erosion from wind and water	Same as above
			• Landscape rehabilitation and revegetation	—Will benefit vegetation species of early successional stages; increases diversity, abundance, etc.
		Increased human access	• Increased human presence	Same as above
	Construction and development	Power plant and facilities	• Clearing, grading for permanent roads buildings, switch yard, etc.	—Direct vegetation destruction and/or modification of vegetation
			• Erosion	—Destruction and/or modification of vegetation —Alteration of ecosystem structure and function (productivity, diversity, nutrient cycling, etc.)
			• Increased human presence	—Increases risk of man-caused fire
			• Improper disposal of garbage and other wastes	—Modifies nutrient cycling
		Transmission lines and pipelines	• Clearing lanes	—Direct destruction and/or modification of vegetation —Alteration of ecosystem structure and function (productivity, diversity, nutrient cycling, etc.)
			• Increased human presence	—Increases risk of man-caused fire
			• Erosion	Same as above
	Operation	Power plant and facilities operation and maintenance	• Thermal discharges to streams and atmosphere	—Modification of terrestrial and aquatic ecosystems (productivity, diversity, etc.)
			• Increased human presence	—Increases risk of man-caused fires
			• Erosion	Same as under test drilling although on a larger, permanent scale
			• Condensate discharge	—Alteration of terrestrial and aquatic vegetation (structure) and function of ecosystems)
			• Discharge of acid washings of "scaled" machinery	—Direct destruction of vegetation —Accumulation of toxic substances in vegetation
			• Herbicidal control of unwanted vegetation	—Toxic to non-target vegetation —Alters nutrient cycling
		Cooling tower operation and maintenance	• Cooling water drift	—Lowered sunlight penetration will decrease photosynthesis —Toxic particles will fallout on vegetation and streams resulting in direct loss and/or reduced productivity, abundance, diversity etc. of vegetation
			• Blowdown discharge	—Contamination and/or alteration of terrestrial and aquatic flora —Could kill vegetation
			• Thermal discharges	Same as above

Resource	Phase	Activity	Change	Impact
		Reinjection	• Alteration of surface and groundwater quantity and quality	—Destruction and/or modification of terrestrial and aquatic vegetation dependent on surface and groundwater (bogs, marshes, riparian)
		Transmission line operation and maintenance	• Increased human access	—Increases risk of man-caused fires
			• Increased "edge" effect due to vegetation manipulation	—Edge associated flora will benefit (increased abundance, diversity, productivity, etc.)
Archaeological/ Historical	Test Drilling	Road building, pad and sump construction	• Cut and fill, grading	—Obliteration of archaeological and/or historical sites
	Construction and Development	Power plant, transmission and pipe lines	• Clearing and grading, clearing lanes, etc.	—Obliteration of archaeological and/or historical sites
Recreation	Exploration	Aerial surveys	• Increased aircraft noise	—Distracting to some forms of recreation (hunting, hiking, fishing, etc.) —Disturbing to humans in campgrounds, summer homes, and wilderness environments
		Gradient test hole drilling	• Increased noise	Same as above
	Test Drilling	Road building, pad and sump construction	• Increased human presence	—More people in primitive or remote recreation areas
		Drilling and production testing	• Increased noise	Same as above
			• Air emissions	—Irritating to adjacent landowners and/or users
		Well blowout	• Increased noise	Same as above
	Construction and Development	Power plant and facilities	• Increased noise	Same as above
			• Increased human presence	Same as above
			• Exclusive use of acreage	—Effectively eliminates some forms of recreation
		Transmission lines	• Increased human presence	Same as above
		Pipelines	• Increased noise	Same as above
	Operation	Power plant operation and maintenance	• Increased noise	Same as above
			• Increased human presence	Same as above
			• Emission of non-condensable gases	—Unhealthy or offensive to adjacent property owners and/or recreationists
		Cooling tower operation and maintenance	• Increased noise	Same as above
Grazing	Exploration	Aerial surveys	• Increased aircraft noise	—Possible disruption (scattering) of livestock
		Gradient test hole drilling	• Increased noise	—Disturbance of livestock
		Explosives and seismic exploration	• Increased risk of man-caused fires	—Alteration of grazing commodities
			• Increased noise	—Disturbance of livestock
	Test Drilling	Road building, pad and sump construction	• Increased access to remote areas	—Improved access for grazing livestock (e.g. trucking, driveways, etc.)

Resource	Phase	Activity	Change	Impact
		Drilling and production testing	• Increased noise	Same as above
		Well abandonment	• Revegetation	—Possible to increase livestock forage production
	Construction and Development	Power plant and facilities	• Clearing, grading excavation	—Destruction of forage plants
			• Exclusive use of acreage	—Effectively precludes grazing on some lands
		Transmission and pipelines	• Clearing operations	—Destroys and alters forage plant communities
	Operation	Power plant operation and maintenance	• Emission of non-condensable gases	—Potentially harmful to livestock (poisoning, illness, etc.)
		Cooling tower operation and maintenance	• Blowdown and condensate discharge	—Potentially harmful to livestock (poisoning, illness, etc.)
		Transmission line maintenance	• No overstory to shade plants	—Increased forage for livestock
Non Threatened and Endangered Wildlife	Exploration	Aerial surveys	• Increased noise (aircraft)	—Temporary disturbance of wildlife. No significant alterations of behavior, physiology, etc. if flights are short, relatively infrequent, and do not harass wildlife
		ORV travel	• Increased noise	—Insignificant disturbance if vehicles are legally muffled
		Explosives and seismic exploration	• Increased noise	—Temporary disturbance of wildlife
		Drilling shallow gradient holes	• Accidental discharge of drilling wastes, mud, geothermal fluids, chemicals, etc.	—Poisoning of terrestrial invertebrates, soil flora and fauna, vegetation and wildlife —Alteration of surface water quality and quantity which affects wildlife through loss of food, habitat, interference with feeding and behavior, etc. —Encourages growth of nuisance organisms —Alteration of groundwater quality and quantity which affects the diversity, productivity, and quantity of vegetation dependent on water table (riparian, marshes, potholes, etc.) and dependent wildlife
			• Increased noise	—Temporary disturbance of wildlife, usually minimal and temporary;
			• Increased human presence	—Increased humen-wildlife conflicts —Some wildlife will avoid the area and thereby lose use of that habitat for feeding, security, nesting, wintering, migration, etc. —Limits the ability of some wildlife to find food, conduct mating, raise young, and maintain protective awareness
		Camping and housing of personnel	• Increased noise from bivouac	—Temporary disturbance of wildlife
			• Soil/vegetation alteration	—Minimal destruction of soil, vegetation, wildlife, etc.
			• Refuse accumulation	—Improper management of garbage will alter the feeding habits of some wildlife (bears, jays, ravens, etc.)

Resource	Phase	Activity	Change	Impact
	Test Drilling	Road, drill pad and sump construction	• Clearing, grading, cut and fill, excavation, etc.	—Crushing of small wildlife (small mammals, reptiles, amphibians, invertebrates) —Sensitive wildlife species will avoid area thereby losing use of the habitat (birds of prey, wolverine, etc.) —Reduction of cover and food for resident wildlife —Disruption and/or elimination of wildlife breeding, nesting, brooding, resting, and rearing activities —Interferes with migration of big game —Alters predator/prey relationships
			• Herbicidal control of unwanted vegetation	—Toxic to non-target vegetation and associated wildlife
			• Accidental discharge of drilling wastes, mud, geothermal fluids, atc.	Same as under exploration although on a larger scale
			• Wildlife dispersal to surrounding habitat	—Increases stress, predation, etc. on resident wildlifa populations and habitat; alters species composition, diversity, abundance, etc.
			• Increased vehicular traffic	—Increased collisions with wildlife and inevitable loss —Increases stress on wildlife populations
			• Increased noise levels	—Interferas with predator/prey relationships, reproduction (courting, mating, nesting, rearing), resting and/or hibernation, feeding, migration, etc.
			• Erosion	—Reduces breeding and nesting sites, covar, and/or other important wildlife habitat —Reduces food and/or water availability
			• Increased human presenca	Same as under exploration although on a larger scale
			• Improper disposal of food-related garbaga and other waste	—Alters feeding habits of some wildlife species, espacially black bears
		Equipment maintenance	• Discharge of detergents, compounds (oil, gas, etc.)	—Pollution of terrestrial ecosystems (poisoning of wildlife, sterility, etc.)
		Blooie line	• Increased noise	Same as above
		Drilling and Production testing	• Increased noise levels	Same as above
			• Release of gases, vapors, and toxic liquids	—Modification of atmosphere and dependent wildlife —Alteration of terrestrial ecosystems (direct mortality of vegetation and animals, reduced productivity, decreased plant vigor, etc.)

Resource	Phase	Activity	Change	Impact
				—Unpleasant odors may impair certain wildlife functions: hunting by smell, individual recognition, etc.
		Well blowout	• Uncontrolled effluent discharge	—Pollution of terrestrial ecosystems; poisoning of insects, small mammals, birds, etc.
			• Thermal pollution	—Modification of atmosphere and disturbance of wildlife dependent on air space for travel, feeding, etc. (birds, bats, insects)
			• Increased noise levels	Same es ebove
		Abandonment of wells	• Dismantling and grading	—Minimum disturbance of adjacent habitat; most activity is on occupied site
			• Increased noise levels	—Temporary disturbance of wildlife
			• Increased human presence	Same as under exploration:
			• Erosion from wind and water	Same as above
			• Landscape rehabilitation and revegetation	—Will benefit wildlife species associated with early successional stages: increases abundance, diversity, etc.
		Increased Human access	• Increased human presence	Same as under exploration
	Construction and Development	Power plant and facilities	• Clearing and grading for permanent roads, buildings, switch yard, etc.	Same as under test drilling although on a larger scale: —Crushing of the small wildlife... —Sensitive wildlife species avoidance... —Reduction of cover and food... —Disruption and/or elimination... —Interferes with migration... —Alters predator/prey relationships
			• Increased air pollution	—Direct loss of wildlife due to poisoning by toxic materials —Damage to supportive habitat —Interference with wildlife behavior, physiology, predator/prey relationships, etc.
			• Wildlife dispersal to surrounding habitat	Same as under test drilling although on a larger, permanent scale: —Increases stress, predation...
			• Increased vehicular traffic	Same as under test drilling although on a lerger, permanent scale: —Increases collisions with wildlife... —Increased stress...
			• Increased noise levels	Seme as under test drilling: —Interferes with predator/prey...
			• Erosion	Same as under test drilling although on a lerger scale: —Reduces breeding and nesting... —Reduces food and/or water...
			• Increased human presence	Same as under exploration although on a larger scale: —Increased human-wildlife conflicts... —Some wildlife will avoid... —Limits the ability of some wildlife...

Resource	Phase	Activity	Change	Impact
				—Increases opportunity for game poaching... —Increases demand on wildlife associated recreation (hunting)
			• Improper disposal of garbage and other wastes	Same as under test drilling although on a larger scale: —Alters feeding habits...
		Transmission lines and pipelines	• Clearing lanes	—Temporary dispersal of wildlife with associated stresses to the populations, and habitat loss for feeding, breeding sites, cover, etc. —Early successional wildlife species will increase in abundance, diversity, etc.
			• Increased noise presence	Same as under exploration; usually temporary but on a larger scale
			• Increased noise	Same as under test drilling
			• Erosion	Same as above
	Operation	Power plant operation and maintenance	• Thermal discharges to atmosphere	—Modification of atmosphere and disturbance of wildlife dependent on air space for travel, feeding, etc. (birds, bats, insects)
			• Increased noise	Same as under test drilling: —Interferes with predator/prey...
			• Increased human presence (permanent)	Same as under exploration although on a larger, permanent scale: —Increased human-wildlife conflicts —Some wildlife will avoid... —Limits the ability of some wildlife... —Increases hunting opportunities —Increases opportunity for poaching
			• Erosion	Same as under test drilling although on a larger, permanent scale: —Reduces breeding and nesting... —Reduces food and/or water...
			• Condensate discharge	—Toxic to terrestrial habitats and associated wildlife
			• Discharge of acid washings of "scaled" machinery	—Toxic salts and chemicals will destroy and/or modify terrestrial ecosystems
			• Emission of noncondensable gases	—Accumulation of toxic substances in food chains causing death, sterility, etc. —Unnatural odors will cause impairment of olfactory senses in some wildlife species
			• Herbicidal control of unwanted vegetation	Same as under test drilling although on larger, permanent scale
		Cooling tower operation and maintenance	• Cooling water drift	—Fog and low clouds will alter temperature, precipitation, etc. patterns thereby modifying wildlife habitat —Toxic particles will fallout on soil, vegetation, wildlife, resulting in direct loss and/or reduced productivity, abundance, diversity, etc. of wildlife
			• Blowdown discharge	—Contamination and/or alteration of terrestrial flora and fauna

Resource	Phase	Activity	Change	Impact
			• Increased noise	Same as under test drilling: —Interferes with predator/prey...
			• Interference with bird movements	—Loss of bird life due to collisions —Alteration of flight patterns (waterfowl) —Alteration of local birds feeding, roosting, and reproductive flights
			• Thermal discharges	Same as above: —Modification of atmosphere... —Modification of aquatic...
		Reinjection	• Alteration of surface and ground water quantity and quality	—Destruction and/or modification of terrestrial ecosystems dependent on surface and ground water (bogs, marshes, riparian, waterfowl, some furbearers, etc.) and associated wildlife
		Transmission line operation and maintenance	• Increased human access (permanent)	—Increases human-wildlife conflicts —Increases opportunity for game poaching and harassment —Increases hunting opportunities
			• Interference with bird movements	Same as under cooling tower (above) although on a larger scale: —Loss of bird life... —Alteration of flight... —Electrocution of birds —Alteration of local birds...
			• Increases raptor perches	—Facilitates hunting and roosting by birds of prey
			• May facilitate animal movements	—Easier for animals to reach seasonal ranges (elk, deer, moose, bears, etc.), feeding, social interactions, etc.
			• Increases "edge effect" due to vegetation manipulation	—Edge associated vegetation and wildlife species will benefit (increased abundance, diversity, etc.)
		Pipeline operation	• Increased thermal pollution	Same as under test drilling although on a smaller scale: —Modification of atmosphere...
			• Barrier to wildlife movement	—Interferes with the ability of big game to reach seasonal ranges

Threatened and Endangered Wildlife

The impacts to Non Threatened and Endangered Wildlife apply as well to Threatened and Endangered species. However, the severity of the impacts will be greater on Threatened and Endangered species because they are restricted by scarcity of habitat, sensitivity to man, and/or low numbers. Below are five major ecological parameters that if impacted will adversely affect Threatened and Endangered wildlife. These are compared to the major changes which are common to phases and most activities. An x indicates the parameters primarily impacted by each change. Refer to the preceding section on Non Threatened and Endangered Wildlife to see where each change and impact occurs for any activity and/or phase.

	Food	Cover	Space	Behavior	Reproduction
• Increased noise				X	X
• Increased human presence			X	X	X
• Habitat destruction and/or alteration	X	X	X		X
• Refuse accumulation	X			X	
• Discharge of toxic materials	X				X
• Erosion	X	X	X		X
• Surface and groundwater effects	X	X			X
• Air pollution				X	X

Resource	Phase	Activity	Change	Impact
Fisheries	Exploration	Explosives and seismic exploration	• Soil/vegetation destruction and/or modification	—Alteration of stream habitat and/or direct destruction of fish, aquatic insects, etc.
		Drilling of shallow gradient holes	• Accidental discharge of drilling wastes, mud, geothermal fluids, chemicals, etc.	—Poisoning of aquatic flora and fauna —Direct destruction of aquatic flora and fauna
			• Increased human presence	—Destruction of aquatic habitat and wildlife
		Camping and housing of personnel	• Soil/vegetation destruction and/or modification	Same as above
			• Refuse accumulation	—Alteration of surface water quality and aquatic wildlife
	Test Drilling	Road, drill pad, and sump construction	• Clearing, grading, cut and fill excavation, etc.	—Crushing of fish, insects, etc. —Destruction and/or alteration of fisheries habitat
			• Herbicidal control of unwanted vegetation	—Toxic to fish and other aquatic organisms —Contaminates aquatic food chains
			• Accidental discharge of drilling wastes, mud, geothermal fluids, etc.	—Poisoning of aquatic flora and fauna —Direct destruction of aquatic habitat
			• Erosion	—Leads to increased stream turbidity and siltation—reduced primary productivity, insect populations, abundance and/or growth of fish, spawning success, etc. —Interferes with fish migration patterns thereby reducing productivity, abundance, spawning, etc. —Stream channel alteration may deteriorate stream and riparian habitats —Reduces breeding and nesting sites, cover, etc.
			• Increased human presence	—Possible destruction of aquatic habitat and fish
		Equipment maintenance	• Discharge of detergents, oil, gas, etc.	—Pollution of aquatic habitat (poisoning of fish, sterility, etc.)
		Drilling and production testing	• Release of gases, vapors, and toxic liquids	—Alters aquatic ecosystems (direct mortality of vegetation, fish, insects, reduced production, etc.)
		Well Blowout	• Uncontrolled effluent discharge	—Pollution and alteration of aquatic ecosystems (poisoning of insects, flora, fish, etc.)
			• Thermal pollution	—Will kill fish, insects, plants, etc. Could severely alter aquatic habitat, fish migration patterns, etc.
		Abandonment of wells	• Erosion from wind and water	Same as above. Erosion should decrease with revegetation. Severest impact will be in the early stages of abandonment.
		Increased human access	• Increases human presence	—Increases fishing

Rasource	Phase	Activity	Change	Impact
	Construction and Development	Power plent end facilitias	• Claaring, grading, cut and fill, atc. for parmanant roads, buildings, switch yard, etc.	—Crushing of fish, insects, etc. —Alteration and/or destruction of fisheries habitat
			• Erosion	Same es ebova
			• Increases human presenca	—Increeses fishing
			• Impropar disposal of garbage and other wastes	—Alteration of surface water quality and associatad aquatic wildlife
		Transmission and pipelines	• Clearing lenes	—Possible destruction of aquetic habitat and wildlife if straams are crossed or parallalad
			• Incraased human presence	Sama es above
			• Erosion	Same es ebova under test drilling
	Operation	Powar plant operation end maintenance	• Thermal dischargas to streams	—Modifies aquetic ecosystems es undar Well Blowout. Will eltar thair structure and function.
			• Increase human prasence (permenent)	Sama as ebove
			• Erosion	Same as undar test drilling
			• Condansata discharge	—Toxic to equatic ecosystem (poisons insacts, fish, plants, atc.)
			• Discharge of acid washings of "scalad" machinery	—Toxic salts and chemicals will dastroy and/or modify aquetic ecosystems (kills fish and other aquatic organisms)
			• Emission of noncondensable gases	—Accumuletion of toxic substenca in equatic food cheins causing daath, sterility, etc.
			• Herbicidal control of unwanted vegetation	—Toxic to non-targat vegatation end equetic wildlife —Conteminetas aquetic food cheins
		Cooling tower operation end maintenance	• Cooling water drift	—Toxic particles will fallout on streems, resarvoirs, etc. resulting in direct loss and/or reduced productivity, abundanca, diversity, etc. of fish, insects, flora, etc.
			• Blowdown discharga	—Contemination end/or altaration of aquatic flore end feuna —Will kill some fish, insects, plants, etc.
			• Tharmal discharges	Same as above
		Rainjection	• Alteration of surface end ground water quantity and quality	—Destruction and/or modification of aquatic acosystems dapandant on surface and ground weter (bogs, mershas, riperien) end associeted wildlifa
		Transmission and pipalines operation end maintenance	• Increesed human eccass (permanent)	Sema as undar test drilling although permenant
Timber	Exploration	Explosives and saismic exploration	• Incraasas risk of man-caused firas (equipment usa)	—Fires could jaoperdize timber commodity

Resource	Phase	Activity	Change	Impact
	Test Drilling	Roed building, pad and sump construction	• Soil/vegetation disturbance	— Destruction of trees
	Construction and development	Power plant and facilities	• Exclusive use of acreage	— Effectively eliminates timber harvest
		Transmission lines	• Clearing and grading	— Destruction of trees
		Pipelines	• Clearing lanes	— Destruction of trees
	Operation	Power plant, transmission lines, and other facilities	• Exclusive use of acreage	— Effectively eliminates timber harvest
Visual	Exploration	Gradient test hole drilling	• Presence of drill rig • Drill cutting piles	— Temporary visual distraction — Local visual scar
	Test drilling	Road building, pad and sump construction	• Man-made feature on landscape	— Distracting from natural setting (in most cases)
		Well Blowout	• Uncontrolled emissions	— Visually distracting
	Construction and development	Power plant and facilities	• Clearing and grading	— Visual disturbance
		Transmission and pipelines	• Clearing lanes	— Visual disturbance
	Operation	Power plant, cooling tower, transmission and pipeline	• Permanent industrial complex	— Permanent alteration of the visual character (e.g. from forested to industrial)
Wilderness and Yellowstone National Park	Exploration	Aerial surveys	• Increased noise (aircraft)	— Temporary intrusion on quiet and solitude of wilderness
		ORV travel	• Increased noise	Same as above
		Explosive and seismic exploration	• Increased noise	Same as above: — Temporary intrusion...
		Drilling of shallow gradient holes	• Increased noise	Same as above, although slightly more permanent
			• Air pollution from vehicles and construction equipment	— Air quality will be degraded
	Test Drilling	Road, drill pad, and sump construction	• Increased noise	Same as under exploration although on larger, permanent basis: — Intrusion on quiet...
		Blooie Line operation	• Increased noise	Same as above: — Intrusion on quiet...
		Drilling and production testing	• Increased noise	Same as above: — Intrusion on quiet...
			• Release of gases and vapors	— Unpleasant odors will alter wilderness air quality
			• Presence of drilling facilities	— Modification of wilderness visual quality
		Well blowout	• Uncontrolled increase in noise	Same as above: — Intrusion on quiet...
			• Uncontrolled release of gases and vapors	Same as above: — Unpleasant odors will...
	Construction and development	Power plant and facilities	• Increased air pollution	Same as under exploration although on permanent, larger scale: — Air quality will be degraded
			• Increased noise	Same as under test drilling: — Intrusion on quiet...

Resource	Phase	Activity	Change	Impact
		Transmission line and pipeline	• Increased noise	Same as under exploration: —Temporary intrusion...
	Operation	Power plant operation and maintenance	• Thermal discharge to atmosphere • Utilization of geothermal fluids	—Modification of wilderness visual quality —Possible alteration of YNP geothermal features
			• Increased noise	Same as under test drilling: —Intrusion on quiet...
			• Emission of noncondensable gases	—Unnatural odors will alter wilderness air quality
			• Presence of facilities	Same as under test drilling: —Modification of wilderness visual...
		Cooling tower operation and maintenance	• Thermal discharges and cooling water drift	—Modification of wilderness visual quality
			• Increased noise	Same as above: —Intrusion on quiet...
			• Presence of facilities	Same as above: —Modification of wilderness visual...
		Transmission lines and pipeline	• Presence of facilities	Same as above: —Modification of wilderness visual...
Transportation System	Exploration	Gradient test hole drilling	• Increases heavy equipment use	—Increased maintenance of transportation system
	Test Drilling	Road building, pad and sump construction	• Increased access	—More roads to maintain and/or close
	Construction and development	Road building	• Increased access	Same as above
	Operation	Equipment travel (trucks, cars)	• Increased use of existing roads	—Increased maintenance of transportation systems
Socio-Economic	Exploration	Aerial surveys	• Increase inmigration See Appendix G	—Slight population increase —Slight employment increase
			• Increased revenue to economy See Appendix H	—Slight increase in income —Slight increase in sales tax revenues —Continuing geothermal lease income to local government —Slight increase in land values
			• Change in community attitudes See Appendix —	—Community attitudes become positive or negative toward geothermal development depending on the perceived effect of geothermal development on the community
		Surface surveys	• Increased inmigration See Appendix G	—Slight population increase
			• Increased revenue to economy See Appendix H	—Slight employment increase —Slight income increase —Slight increase in land values —Slight increase in sales tax revenues —Slight increase in state income tax revenues —Continuing geothermal lease income to local government

Resource	Phase	Activity	Change	Impact
			• Change in community attitudes See Appendix I	Same as aerial surveys: —Community attitudes become positive or negative...
		Thermal gradient hole drilling	• Increased inmigration See Appendix G	—Slight population increase —Slight employment increase
			• Increased revenue to economy See Appendix H	Same as aerial surveys: —Slight increase in income —Slight increase in sales tax revenues —Slight increase in state income tax revenues —Continuing geothermal lease income to local government —Slight increase in land values
			• Minor change in land usage	—Small parcels of land are used for drilling sites
			• Housing changes	—Change in type and occupancy level —Recreational homes may be leased to geothermal drilling crews
			• Change in community attitudes See Appendix I	Same as aerial surveys: —Community attitudes become positive or negative...
			• Increased demand on health and social services See Appendix I	—Health manpower needs increase because of drilling crews and increased potential of industrial accidents —Law enforcement requirements increase —Fire protection needs increase slightly —Use of waste water treatment facilities increase slightly —The need for solid waste collection increases slightly
			• Increased demand on educational facilities See Appendix I	—Elementary and secondary schools will have a slight increase in attendance
			• Changes in demand on transportation systems	—Slightly increased use of roads, highways, and air transportation by drilling crews
			• Land use patterns change	—Grazing, timber harvest, and recreation no longer occur on those small tracts of land used for drilling
	Test Drilling	Road Construction	• Increased inmigration See Appendix G	Same as exploration but to a greater extent: —Population increase —Employment increase
			• Increased revenue to economy See Appendix H	Same as exploration but to a greater extent: —Increase in income —Increase in sales tax revenues —Increase in state income tax revenues —Continuing geothermal lease income to local government —Increase in land values
			• Change in community attitudes See Appendix I	Same as exploration but to a greater extent: —Community attitudes become more positive or negative...

Resource	Phase	Activity	Change	Impact
			• Minor change in land usage	Same as exploration but to a greater extent: —More land is used for geothermal development and support activities
			• Housing changes	Same as exploration but to a greater extent: —Change in type and occupancy level...
			• Increased demand for social and health service See Appendix I	Same as exploration but to a greater extent: —Health manpower needs... —Law enforcement... —Fire protection... —Use of waste water treatment facilities... —The need for solid waste collection
			• Increased demand on educational facilities See Appendix I	Same as exploration but to a greater extent: —Elementary and secondary schools
			• Increased demand on transportation systems	Same as exploration but to a greater extent: —Increased use of road and high-ways...
			• Land use patterns change	Same as exploration but to a greater extent: —Grazing timber harvest and recreation...
			• Some increases in local sale of support goods and services See Appendix H	—Created by local purchases of equipment, construction material, and support services
		Test well drilling, pad and sump construction, etc.	• Increased inmigration See Appendix G	Same as exploration but to a greater extent: —Population increase —Employment increase
			• Increased revenue to economy See Appendix H	Same as exploration but to a greater extent: —Increase in income —Increase in sales tax revenues —Increase in state income tax revenues —Continuing geothermal lease income to local government —Increase in land values
			• Change in community attitudes See Appendix I	Same as exploration but to a greater extent: —Community attitudes become more positive or negative
			• Minor changes in land usage	Same as exploration but to a greater extent: —More land is used for geothermal developments and support activities
			• Housing changes	Same as exploration but to a greater extent:

Resource	Phase	Activity	Change	Impact
				—Change in type and occupancy level...
			• Change in demand for social and health services See Appendix I	Same as exploration but to a greater extent: —Health manpower needs... —Law enforcement... —Fire protection... —Use of waste water treatment facilities... —The need for solid waste collection...
			• Change in demand on education facilities See Appendix I	Same as exploration but to a greater extent: —Elementary and secondary schools
			• Changes in demand on transportation systems	Same as exploration but to a greater extent: —Increased use of roads and highways
			• Land use patterns change	Same as exploration but to a greater extent: —Grazing, timber harvest, and recreation...
			• Some increase in local sales of support goods and services See Appendix H	—Created by local purchases of equipment, construction material, and support services
		Well Blowout	• Health and safety hazard	—Particles under pressure in hot water could injure people nearby —Possibility of burns from steam or hot water
	Construction and Development	Power plant or heating plant facilities	• Increased inmigration See Appendix G	Same as exploration but to a greater extent: —Population increase —Employment increase
			• Increased revenue to economy See Appendix H	Same as exploration but to a greater extent: —Increase in income —Increase in sales tax revenue —Increase in state income tax revenue —Continuing geothermal lease income to local government —Increase in land values
			• Change in community attitudes See Appendix I	Same as exploration but to a greater extent: —Community attitudes become more positive or negative...
			• Minor change in land usage	Same as exploration but to a greater extent: —More land is used for geothermal development and support activities
			• Housing changes	Same as exploration but to a greater extent: —Change in type and occupancy level...

Resource	Phase	Activity	Change	Impact
			• Increased demand for social and health services See Appendix I	Same as exploration but to a greater extent: —Health manpower needs... —Law enforcement... —Fire protection... —Use of waste water treatment facilities... —The need for solid waste collection...
			• Increased demand on educational facilities See Appendix I	Same as exploration but to a greater extent: —Elementary and secondary schools...
			• Increased demand on transportation systems	Same as exploration but to a greater extent: —Increased use of roads and highways...
			• Land use patterns change	Same as exploration but to a greater extent: —Grazing timber harvest and recreation...
			• Some increase in local sales of support goods and services See Appendix H	—Created by local purchases of equipment, construction material, and support services
	Operation	Power plant or heating plant operation and maintenance	• Increased inmigration See Appendix G	Same as exploration but to a greater extent: —Population increase —Employment increase
			• Increased revenue to economy See Appendix H	Same as exploration but to a greater extent: —Increase in income —Increase in sales tax revenue —Increase in state income tax revenue —Continuing geothermal lease income to local government —Increase in land values
			• Change in community attitudes See Appendix I	Same as exploration but to a greater extent: —Community attitudes become positive or negative...
			• Minor change in land usage	Same as exploration but to a greater extent: —More land is used for geothermal development and support activities
			• Housing changes	Same as exploration but to a greater extent: —Change in type and occupancy level...

Resource	Phase	Activity	Change	Impact
			• Increased demand for social and haalth services See Appendix I	Same as exploration but to a greater extent: —Health manpower needs... —Law enforcement... —Fire protection... —Use of waste water treatment facilities... —The need for solid waste collection...
			• Increased demand on educational facilities Saa Appendix I	Same as exploration but to a greater extent: —Elementary and secondary schools...
			• Increased demand on transportation systems	Same as exploration but to a greater axtent: —Increasad use of roads and highways...
			• Land use patterns change	—Some land uses that were stoppad during the construction phasa can be resumed near the geotharmal development
			• Some increase in local sale of support goods and services See Appendix H	—Created by local purchases of equipment, construction material, and support services
			• Production of alactricity	—Electricity produced will be competitive with alternative methods
			• Production of heat Sea Appendix J	—Heat may be produced for space heating, industrial, or agricultural use
			• Lease royalty	—Royalty income begins with commercial production
			• Educational facility	—Opportunity for public to laarn about geothermal energy use
Minerals	Exploration	Aerial surveys	•Specific information gathering	—Increases knowledge of geological features —Possible collection of other management data
	Operation	Utilization of geothermal resource	• Extraction of geothermal fluids	—Gradual depletion of the resourca

A few adverse impacts cannot be avoided if geothermal development takes place in the Island Park Geothermal Area. Table 34 summarizes these impacts.

TABLE 34. ADVERSE IMPACTS WHICH CANNOT BE AVOIDED

Soil	Some soil losses are expected, particularly during the first winter following construction operations.
Water Quality	Stream turbidity will occur when large areas are cleared and graded. Some chemical spills may accidently occur which will contaminate portions of streams due to the chemical toxicity.
Wildlife	The loss of habitat for animals requiring a forested environment and a parallel reduction in their numbers is unavoidable if geothermal energy development occurs. Unavoidable losses of elk, deer, bear, and other species sensitive to noise and human presence will be caused by geothermal development and production activities. Certain species may return as they become accustomed to the new conditions. Others unable to make the necessary adaptation will probably be absent throughout the life of the activity.
Fisheries	Chemical or hot water spills will adversely affect the aquatic environment. Toxic substances will kill many aquatic organisms and thermal plumes can block fish migration patterns. Increased stream sedimentation from disturbed areas will cause channel modification and increased turbidity.
Timber Production	Loss of timber yields is an unavoidable impact where clearing occurs for any purpose. A loss of soil fertility due to removal of topsoil on graded and leveled areas will unavoidably retard timber growth rates for up to 100 years following removal of geothermal facilities, unless fertilizers are applied.
Visual Quality	Geothermal facilities can, to some extent, be screened or blended into the background. Because of the extensive network of pipelines, transmission lines, roads, and buildings, however, it is unlikely that all such installations can be blended into the surroundings. Stream plumes from cooling towers likewise cannot be hidden, particularly in winter.
Recreation	Development of geothermal facilities in the IPGA will reduce the area available for recreation. It would also impose unavoidable impacts on the quality of both dispersed and developed site recreation. Although the proposed action is designed to minimize impacts on the recreation resource, it is not possible to introduce such activity into an area without affecting the qualities currently available to recreationists visiting the area.
Fire Risk	The presence of men and equipment essential to geothermal exploration, development, and production will unavoidably increase fire risk. A small increase in the amount of fuel can be expected during construction.
Air Quality	The escape of small quantities of noxious and ordorous gases must be regarded as an unavoidable consequence of geothermal development. Burning of debris produced in clearing for access roads and facility development will result in some smoke pollution. Dust control and watering can effectively control the dust raised along access roads and around earth-moving operations. However, there will be some dust in spite of the preventive measures.
Noise	Higher than present noise levels must be regarded as unavoidable around geothermal operations. The adverse impacts to wildlife, recreation, grazing livestock and adjoining landowners are also considered unavoidable.
Vegetation	Loss and damage of vegetation are unavoidable during all phases of geothermal development. Various activities will either crush or remove vegetation and adversely affect grazing livestock and wildlife.

VI. EVALUATION OF ALTERNATIVES AND DEVELOPMENT OF A PROPOSAL

The evaluation of alternatives is a complex procedure that includes tangible and intangible impacts. Information on each resource was used to form a matrix adapted to fit our situation.

Each impact listed in section V was evaluated by the Geothermal Environmental Statement Team. The impact was assessed by alternative based upon information gathered by the team. This judgement was based upon the team member's knowledge of the resource, the Island Park Geothermal Area, geothermal development, the quantity and quality of information available, and input from other members of the interagency team. Recognized authorities on each resource were consulted to arrive at a consensus of the impact. These assessments were then used in the matrix analysis.

Table 35 is a sample of the matrix used to evaluate each alternative. The rows and columns have been numbered for reference in the following discussion.

1. Where each row (resource) intersects with columns 1-4 (phase) the box is divided into three parts (figure 8):

   —The number (value in the "a" part represents the relative importance of the phase to the resource. The values range from 0 to 1.0 and total 1.0 ($a_1 + a_2 + a_3 + a_4 = 1.0$). The larger the number, the more "important" that phase is to the resource (important infers that **portion** of the total impact on the resource expected to occur in that phase). These values were established by the Geothermal Team collectively.

   —The numbers in the "b" part stand for the total impact a phase will have on the resource. These values were calculated during each member's assessment of the impacts. The values range from 0 to 1.0 and, in general, the larger the number the greater the impact of the phase. These numbers do not and could not define the "true impact". They were arrived at by individual team members and represent only the opinions of experts. Since each alternative is subjected to the assessment in the same manner, the unweighted impact must only be reasonable.

   —The figure (value) in the "c" part is the product of the "a" and "b" boxes ($a_1 \times b_1 = c_1$). This represents the weighted effect of the phase on the resource.

2. After each box has been completed, the **Weighted Effects** (c parts) are summed across each row and establish the value in column 5 ($c_1 + c_2 + c_3 + c_4 = W_1$). This figure ($W_1$) represents the total cumulative effect of all phases of geothermal development on the resource.

3. Column 6 contains the **Weighted Resource Values**. These numbers represent the relative value of each resource on the Island Park Geothermal Area when the sum of the numbers equals 100. These values were determined by resource specialists, land managers and the Geothermal Team on the Targhee and Gallatin National Forests. Twenty-seven people contributed to the value assignments. When ranking the resources and assigning values, each person considered the following criteria:

   - Condition of the resource and its productivity,
   - quantity of the resource (its significance to the IPGA, the Forests, and the Region),
   - accessibility of the resource,
   - uniqueness and quality of the resource,
   - dominance the resource has in relation to the other area resources.

4. In column 7 is the **Total Environment Effects** on the resource of all phases ($W_1 \times R_1 = E_1$). It considers the Weighted Effects of each phase, and the resources' relative importance to the IPGA. These figures are summed vertically to establish an alternatives final "score".

The Total Environmental Effects value (E) and the alternative's total "score" are abstract and have no units. However, they may be used to obtain relative rankings of environmental impacts when compared to other resource values and total "scores". Each resource can be compared within and between alternatives, and alternatives can be compared to each other.

TABLE 35. MATRIX USED TO EVALUATE EFFECTS OF GEOTHERMAL LEASING ALTERNATIVES

EFFECTS OF PHASES / ON RESOURCE	1 EXPLORATION	2 TEST DRILLING	3 CONSTRUCTION & DEVELOPMENT	4 OPERATION	5 TOTAL OF WEIGHTED EFFECTS	6 WEIGHTED RESOURCE VALUES	7 TOTAL ENVIRONMENTAL EFFECTS
(1) SOIL	$\frac{a_1 \quad b_1}{c_1}$	$\frac{a_2 \quad b_2}{c_2}$	$\frac{a_3 \quad b_3}{c_3}$	$\frac{a_4 \quad b_4}{c_4}$	W_1	R_1	E_1
(2) WATER						R_2	E_3
(3) AIR							E
(4) VEGETATION							
(5) FISHERIES							
(6) NON THR... ANGERE... ...RNESS AND YELLO... NATIONAL PARK							
(14) SOCIO-ECONOMIC							
(15) MINERALS (GEOTHERMAL)							
						TOTAL	

FIGURE 8. COMPOSITION OF ONE BOX IN THE MATRIX.

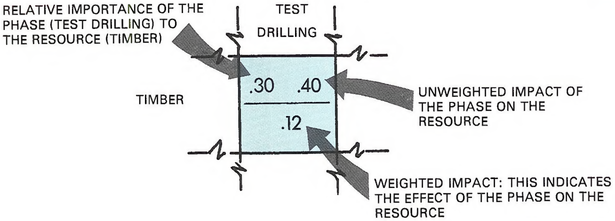

TABLE 36. SUMMARY OF THE EVALUATION OF ALTERNATIVES

RESOURCE	WEIGHTED RESOURCE VALUE	TOTAL ENVIRONMENTAL EFFECTS OF ALTERNATIVE #2	TOTAL ENVIRONMENTAL EFFECTS OF ALTERNATIVE #3	TOTAL ENVIRONMENTAL EFFECTS OF ALTERNATIVE #4	TOTAL ENVIRONMENTAL EFFECTS OF ALTERNATIVE #5	TOTAL ENVIRONMENTAL EFFECTS OF ALTERNATIVE #6
SOIL	4	2.12	1.40	2.12	1.40	2.76
WATER	16	8.32	5.12	8.48	5.12	12.48
AIR	7	4.06	2.45	2.94	2.45	5.39
VEGETATION	5	2.15	1.40	1.90	1.40	3.40
FISHERIES	13	5.72	4.48	4.55	4.68	9.23
NON THREATENED & ENDANAGERED WILDLIFE	9	4.59	3.60	3.78	3.87	7.11
THREATENED & ENDANAGERED WILDLIFE	6	4.32	2.64	2.82	3.30	5.76
TIMBER	11	4.84	3.41	4.84	3.41	9.90
GRAZING	4	1.24	0.96	1.24	0.96	2.32
RECREATION	9	5.04	3.24	5.04	3.42	6.84
VISUAL	6	3.00	2.16	3.12	2.64	4.62
ARCHAEOLOGICAL/HISTORICAL	2	1.04	0.80	1.04	0.80	1.60
WILDERNESS & YELLOWSTONE NATIONAL PARK	3	2.40	1.83	1.95	1.98	2.73
SOCIO-ECONOMIC	3	1.62	1.11	1.11	1.11	1.68
MINERALS (GEOTHERMAL)	2	1.60	1.20	1.20	1.20	2.00
Total		52.06	35.80	46.13	37.74	77.82

This draft environmental statement does not identify a preferred alternative or proposal because:

1. The public has not had an opportunity to consider the various alternatives and comment. By not favoring any one alternative, the public can objectively evaluate and express their concerns on all alternatives.

2. Neither the Forest Service nor BLM has a favored or preferred alternative at this time.

3. Although tentative decision criteria have been developed, the public has not reviewed them and commented on their adequacy. More criteria may eventually be added or the tentative criteria may be modified.

Table 36 is a summary of the evaluation of alternatives two through six. The analysis was not applied to alternative one since that alternative proposes no leasing. Therefore, effects would equal zero as would the total score. Tables 37 through 41 are the matrices for alternatives two through six.

TABLE 37. GEOTHERMAL LEASING ALTERNATIVE NUMBER 2

EFFECTS OF PHASES ON RESOURCE	1 EXPLORATION	2 TEST DRILLING	3 CONSTRUCTION & DEVELOPMENT	4 OPERATION	5 TOTAL OF WEIGHTED EFFECTS	6 WEIGHTED RESOURCE VALUES	7 TOTAL ENVIRONMENTAL EFFECTS
(1) SOIL	.01 .40 .004	.20 .40 .08	.65 .60 .39	.14 .40 .056	.53	4	2.12
(2) WATER	.02 .36 .007	.18 .62 .11	.45 .49 .22	.35 .51 .178	.52	16	8.32
(3) AIR	.01 .40 .004	.09 .60 .054	.30 .52 .156	.60 .60 .36	.58	7	4.06
(4) VEGETATION	.05 .40 .02	.30 .37 .111	.50 .46 .23	.15 .45 .068	.43	5	2.15
(5) FISHERIES	.10 .36 .036	.20 .38 .076	.60 .48 .288	.10 .42 .042	.44	13	5.72
(6) NON THREATENED & ENDANGERED WILDLIFE	.05 .40 .02	.10 .40 .04	.55 .55 .30	.30 .50 .15	.51	9	4.59
(7) THREATENED & ENDANGERED WILDLIFE	.05 .60 .03	.10 .65 .065	.45 .75 .34	.40 .70 .28	.72	6	4.32
(8) TIMBER	.01 .20 .002	.30 .40 .12	.59 .50 .295	.10 .20 .02	.44	11	4.84
(9) GRAZING	.10 .20 .02	.20 .20 .04	.40 .40 .16	.30 .30 .09	.31	4	1.24
(10) RECREATION	.10 .40 .04	.20 .60 .12	.60 .60 .36	.10 .40 .04	.56	9	5.04
(11) VISUAL	.10 .60 .06	.20 .40 .08	.40 .60 .24	.30 .40 .12	.50	6	3.00
(12) ARCHAEOLOGICAL/HISTORICAL	- - -	.40 .40 .16	.60 .60 .36	- - -	.52	2	1.04
(13) WILDERNESS AND YELLOWSTONE NATIONAL PARK	.05 .60 .03	.10 .70 .07	.40 .85 .34	.45 .80 .36	.80	3	2.40
(14) SOCIO-ECONOMIC	.05 .20 .01	.10 .28 .028	.65 .62 .403	.20 .47 .094	.54	3	1.62
(15) MINERALS (GEOTHERMAL)	- - -	- - -	- - -	1.0 .80 .80	.80	2	1.60
						TOTAL	52.06

TABLE 38. GEOTHERMAL LEASING ALTERNATIVE NUMBER 3

EFFECTS OF PHASES ON RESOURCE	1 EXPLORATION	2 TEST DRILLING	3 CONSTRUCTION & DEVELOPMENT	4 OPERATION	5 TOTAL OF WEIGHTED EFFECTS	6 WEIGHTED RESOURCE VALUES	7 TOTAL ENVIRONMENTAL EFFECTS
(1) SOIL	.01 .20 .002	.20 .30 .06	.65 .40 .26	.14 .20 .028	.35	4	1.40
(2) WATER	.02 .02 .004	.18 .45 .081	.45 .26 .117	.36 .33 .115	.32	16	5.12
(3) AIR	.01 .20 .002	.09 .40 .036	.30 .24 .072	.60 .40 .24	.35	7	2.45
(4) VEGETATION	.05 .30 .015	.30 .20 .060	.50 .35 .175	.15 .20 .030	.28	5	1.40
(5) FISHERIES	.10 .30 .03	.20 .25 .05	.60 .35 .21	.10 .25 .025	.32	13	4.48
(6) NON THREATENED & ENDANGERED WILDLIFE	.05 .30 .015	.10 .30 .030	.55 .40 .220	.30 .30 .09	.36	9	3.60
(7) THREATENED & ENDANGERED WILDLIFE	.05 .20 .010	.10 .30 .03	.45 .45 .20	.40 .50 .20	.44	6	2.64
(8) TIMBER	.01 .20 .002	.30 .20 .06	.59 .40 .236	.10 .10 .01	.31	11	3.41
(9) GRAZING	.10 .20 .02	.20 .20 .04	.40 .30 .12	.30 .20 .06	.24	4	0.96
(10) RECREATION	.10 .20 .02	.20 .40 .08	.60 .40 .24	.10 .20 .02	.36	9	3.24
(11) VISUAL	.10 .20 .02	.20 .20 .04	.40 .60 .24	.30 .20 .06	.36	6	2.16
(12) ARCHAEOLOGICAL/HISTORICAL	- - -	.40 .40 .16	.60 .40 .24	- - -	.40	2	0.80
(13) WILDERNESS AND YELLOWSTONE NATIONAL PARK	.05 .40 .02	.10 .60 .06	.40 .60 .24	.45 .65 .293	.61	3	1.83
(14) SOCIO-ECONOMIC	.05 .16 .008	.10 .22 .022	.65 .42 .273	.20 .31 .062	.37	3	1.11
(15) MINERALS (GEOTHERMAL)	- - -	- - -	- - -	1.0 .60 .60	.60	2	1.20
						TOTAL	35.80

TABLE 39. GEOTHERMAL LEASING ALTERNATIVE NUMBER 4

EFFECTS OF PHASES ON RESOURCE	1 EXPLORATION	2 TEST DRILLING	3 CONSTRUCTION & DEVELOPMENT	4 OPERATION	5 TOTAL OF WEIGHTED EFFECTS	6 WEIGHTED RESOURCE VALUES	7 TOTAL ENVIRONMENTAL EFFECTS
(1) SOIL	.01 .20 .002	.20 .40 .08	.65 .60 .39	.14 .40 .056	.53	4	2.12
(2) WATER	.02 .36 .007	.18 .65 .117	.45 .49 .221	.35 .53 .186	.53	16	8.48
(3) AIR	.01 .20 .002	.09 .50 .045	.30 .24 .072	.60 .50 .30	.42	7	2.94
(4) VEGETATION	.05 .40 .02	.30 .30 .09	.50 .38 .19	.15 .54 .081	.38	5	1.90
(5) FISHERIES	.10 .36 .036	.20 .30 .06	.60 .40 .24	.10 .18 .018	.35	13	4.55
(6) NON THREATENED & ENDANGERED WILDLIFE	.05 .25	.10 .36 .036	.55 .43 .237	.30 .43 .129	.42	9	3.78
(7) THREATENED & ENDANGERED WILDLIFE	.05 .25 .013	.10 .30 .03	.45 .51 .23	.40 .51 .20	.47	6	2.82
(8) TIMBER	.01 .20 .002	.30 .40 .12	.59 .50 .295	.10 .10 .01	.44	11	4.84
(9) GRAZING	.10 .20 .02	.20 .20 .04	.40 .40 .16	.30 .30 .09	.31	4	1.24
(10) RECREATION	.10 .40 .04	.20 .60 .12	.60 .60 .36	.10 .40 .04	.56	9	5.04
(11) VISUAL	.10 .60 .06	.20 .50 .10	.40 .60 .24	.30 .40 .12	.52	6	3.12
(12) ARCHAEOLOGICAL/HISTORICAL	- - -	.40 .40 .16	.60 .60 .36	- - -	.52	2	1.04
(13) WILDERNESS AND YELLOWSTONE NATIONAL PARK	.05 .40 .02	.10 .60 .06	.40 .70 .28	.45 .65 .293	.65	3	1.95
(14) SOCIO-ECONOMIC	.05 .16 .008	.10 .22 .022	.65 .42 .273	.20 .31 .062	.37	3	1.11
(15) MINERALS (GEOTHERMAL)	- - -	- - -	- - -	1.0 .60 .60	.60	2	1.20
						TOTAL	46.13

TABLE 40. GEOTHERMAL LEASING ALTERNATIVE NUMBER 5

EFFECTS OF PHASES ON RESOURCE	1 EXPLORATION	2 TEST DRILLING	3 CONSTRUCTION & DEVELOPMENT	4 OPERATION	5 TOTAL OF WEIGHTED EFFECTS	6 WEIGHTED RESOURCE VALUES	7 TOTAL ENVIRONMENTAL EFFECTS
(1) SOIL	.01 .20 .002	.20 .30 .06	.65 .40 .26	.14 .20 .028	.35	4	1.40
(2) WATER	.02 .20 .004	.18 .45 .081	.45 .26 .117	.35 .33 .116	.32	16	5.12
(3) AIR	.01 .20 .002	.09 .40 .036	.30 .24 .072	.60 .40 .24	.35	7	2.45
(4) VEGETATION	.05 .40 .02	.30 .26 .078	.50 .30 .150	.15 .22 .033	.28	5	1.40
(5) FISHERIES	.10 .44 .044	.20 .25 .05	.60 .40 .24	.10 .25 .025	.36	13	4.68
(6) NON THREATENED & ENDANGERED WILDLIFE	.05 .05 .025	.10 .35 .035	.55 .49 .270	.30 .32 .096	.43	9	3.87
(7) THREATENED & ENDANGERED WILDLIFE	.05 .40 .02	.10 .40 .04	.45 .60 .27	.40 .55 .22	.55	6	3.30
(8) TIMBER	.01 .20 .002	.30 .20 .06	.59 .40 .236	.10 .10 .01	.31	11	3.41
(9) GRAZING	.10 .20 .02	.20 .20 .04	.40 .30 .12	.30 .20 .06	.24	4	0.96
(10) RECREATION	.10 .40 .04	.20 .40 .08	.60 .40 .24	.10 .20 .02	.38	9	3.42
(11) VISUAL	.10 .60 .06	.20 .40 .08	.40 .60 .24	.30 .20 .06	.44	6	2.64
(12) ARCHAEOLOGICAL/HISTORICAL	- - -	.40 .40 .16	.60 .40 .24	- - -	.40	2	0.80
(13) WILDERNESS AND YELLOWSTONE NATIONAL PARK	.05 .45 .023	.10 .65 .065	.40 .70 .28	.45 .65 .293	.66	3	1.98
(14) SOCIO-ECONOMIC	.05 .16 .008	.10 .22 .022	.65 .42 .273	.20 .31 .062	.37	3	1.11
(15) MINERALS (GEOTHERMAL)	- - -	- - -	- - -	1.0 .60 .60	.60	2	1.20
						TOTAL	37.74

TABLE 41. GEOTHERMAL LEASING ALTERNATIVE NUMBER 6

EFFECTS OF PHASES ON RESOURCE	1 EXPLORATION	2 TEST DRILLING	3 CONSTRUCTION & DEVELOPMENT	4 OPERATION	5 TOTAL OF WEIGHTED EFFECTS	6 WEIGHTED RESOURCE VALUES	7 TOTAL ENVIRONMENTAL EFFECTS
(1) SOIL	.01 .45 .005	.20 .45 .09	.65 .80 .52	.14 .55 .077	.69	4	2.76
(2) WATER	.02 .80 .016	.18 .87 .156	.45 .74 .33	.35 .78 .273	.78	16	2.48
(3) AIR	.01 .60 .006	.09 .85 .077	.30 .68 .204	.60 .80 .48	.77	7	5.39
(4) VEGETATION	.05 .80 .04	.30 .60 .18	.50 .67 .335	.15 .82 .123	.68	5	3.40
(5) FISHERIES	.10 .80 .08	.20 .65 .13	.60 .70 .42	.10 .80 .08	.71	13	9.23
(6) NON THREATENED & ENDANGERED WILDLIFE	.05 .76 .038	.10 .68 .068	.55 .78 .429	.30 .86 .258	.79	9	7.11
(7) THREATENED & ENDANGERED WILDLIFE	.05 .80 .04	.10 .90 .09	.45 1.0 .45	.40 .95 .38	.96	6	5.76
(8) TIMBER	.01 .40 .004	.30 .60 .18	.59 .70 .413	.10 .30 .30	.90	11	9.90
(9) GRAZING	.10 .40 .04	.20 .20 .04	.40 .60 .24	.30 .60 .18	.58	4	2.32
(10) RECREATION	.10 .60 .06	.20 .80 .16	.60 .80 .48	.10 .60 .06	.76	9	6.84
(11) VISUAL	.10 1.0 .10	.20 .60 .12	.40 1.0 .40	.30 .50 .15	.77	6	4.62
(12) ARCHAEOLOGICAL/HISTORICAL	- - -	.40 .80 .32	.60 .80 .48	- - -	.80	2	1.60
(13) WILDERNESS AND YELLOWSTONE NATIONAL PARK	.05 .60 .03	.10 .70 .07	.40 1.0 .40	.45 .90 .405	.91	3	2.73
(14) SOCIO-ECONOMIC	.05 .25 .013	.10 .32 .032	.65 .64 .416	.20 .48 .096	.56	3	1.68
(15) MINERALS (GEOTHERMAL)	- - -	- - -	- - -	1.0 1.0 1.0	1.0	2	2.00
						TOTAL	77.82

VII. MANAGEMENT REQUIREMENTS, CONSTRAINTS, AND MITIGATING MEASURES

These requirements, constraints, and mitigating measures apply to geothermal leasing considered anywhere within the IPGA. They will be used as guidelines for specific lease stipulations if and when geothermal leasing/development becomes a reality. Considerations like width of stream protective zones, distance of noise from human use, location of drilling/construction sites from existing roads or other developments, etc. must be determined on a case by case or site by site basis.

Mitigation of environmental impacts stemming from geothermal exploration and development will be accomplished by enforcing federal, state, and local laws and regulations; geothermal exploration and leasing regulations; geothermal operating regulations; Geothermal Resources Operational Orders (GRO's); lease and land use stipulations (see Appendix K for example lease form); and by applying existing, developing, and still to be developed technologies. If applicable standards cannot be met, construction will be delayed pending solution of the problems.

Although the number of geothermal installations in the world is limited, considerable technical and operational information is known. Drilling methods and techniques for handling high pressure fluids have been transferred, with appropriate modification, from the petroleum industry to the geothermal industry. Knowledge of environmental causes, effects, and remedial or preventive measures specifically relating to geothermal development ranges from adequate to limited.

Some known environmental impacts can be prevented. Others can be anticipated and environmental protection planned. Certain impacts can only be hypothesized. Contingencies included under general regulations may provide a means for corrective action in the event hypothetical impacts become a reality. If unacceptable environmental impacts cannot be corrected, development will not be permitted.

If a significant geothermal resource is discovered in the area, development will probably occur slowly over several years, for technical, economic, and environmental reasons. A prolonged development period tends to be a mitigating measure because problems discovered in initial operations may be solved in succeeding operations. If problems develop which cannot be satisfactorily solved, regulations require shut-down of operations until corrective action is taken.

Monitoring is required for potential impacts of exploration, development, and production of geothermal resources. Short-term impacts such as those on noise and air quality will be monitored by the lessee under supervision of the U.S. Geological Survey. Monitoring changes that cannot be attributed to leases will be the responsibility of the surface managing agency. Monitoring activities must be initiated prior to development so that impacts can be analyzed before and after assessment.

EXPLORATION

Noise, dust and vegetation crushing due to off-road vehicle (ORV) travel—Travel will be restricted to existing roads as much as possible. Off-road travel will be coordinated with the surface land managing agency to avoid disturbing wildlife during important periods in their life cycles. ORV travel will be excluded from stream courses and areas of ephemeral surface flow.

Explosives and seismic exploration—No blasting will be allowed in marshes or near open bodies of water, springs, or known sensitive habitats. These activities will not take place in areas used by sensitive wildlife species during breeding or other important periods in the life cycle. To offset the increased risk of fire, the following will be incorporated into site selection and planning efforts: an increased level of detection (lookouts, aircraft, etc.); adequate communication; education of personnel involved; enforcement of all laws, regulations and guidelines; and close coordination with the surface managing agency to avoid periods of high fire danger.

Clearing access routes—Proper planning and site selection is effective mitigation. Use of natural breaks in vegetation (crests and ridges) is advantageous, while surface water and riparian habitat will be avoided. Minimum vegetation will be cleared. Temporary access routes will be reclaimed to as near original condition as possible. This may require scarification, reseeding, fertilization, etc. Routes will be physically and administratively closed after drilling is completed. To reduce fire hazard, prevention coordination with the surface managing agency an an approved fire plan will be required.

Increased noise—Mufflers on the drill rig engine will reduce noise. However, special problems with unique wildlife may arise on a site-specific basis. Additional muffling or alternative site selection may be required. Insofar as possible, operations will be kept well back from residences, recreation sites, administrative sites, recreation roads, and wilderness access points.

Noise limitations should conform, as an initial minimum, to the regulations issued by the U.S. Geological Survey for geothermal operations on Federal lands: i.e. not to exceed 65 db(A) at the lease boundary or one-half mile from the source, whichever is greater.

Preparation of drilling area— Generally, site preparation is not necessary. Proper site selection will minimize most soil/vegetation disturbance and/or modification. Sites will be located away from surface water to prevent pollution from spills, soil erosion, etc. Drilling sites will be designed with a levee surrounding each site to control runoff and prevent erosion and stream sedimentation. Runoff should be channeled into holding ponds to allow slow percolation.

Discharge of drilling wastes, mud, etc. — Drill cuttings will be transported to a dump site. Geothermal fluids or toxic substances will be held in temporary holding ponds until proper disposal is arranged.

Increased human presence— Human presence will be temporary and localized in the vicinity of the drill site. Complete mitigation is impossible; however, proper education of crews will reduce human-wildlife conflicts and lessen impacts on wildlife populations.

Drilling of shallow holes— Interaquifer transfer of waters with different qualities through encased holes will not be allowed.

Camping and housing personnel— Chosen sites should minimize disturbance of soil/vegetation, surface waters, and wildlife. Bivouacs will not be allowed in important wildlife habitats during critical periods of important species life cycles: for example, waterfowl concentration areas during migration, near raptor nests during the nesting and fledgling periods, etc. Streamside and riparian habitat locations will be discouraged. Camp sanitation plans will not allow litter and garbage to be scattered. Bear-proof containers will be required and all litter and garbage will be removed daily. Self-contained chemical toilets will be discharged into appropriate facilities. Fire prevention plans and fuel treatment around camps will be coordinated with the surface land managing agency.

TEST DRILLING

General construction— Construction is not specific to any particular phase, although construction impacts commonly begin in the test drilling phase. These include roads, drill pads and sumps, foundations for buildings, parking lots, and storage areas. Impacts have been identified for each phase, however, mitigation measures apply to impacts associated with construction in all phases.

The most effective mitigation for direct impacts to soil/vegetation, water resources, fish and wildlife or resource management structures is proper planning and site selection. Important and/or sensitive habitats have been excluded or deferred from leasing (certain big game winter ranges, swan wintering areas, critical portions of migration routes, etc.) Excessive road building will be prevented. Timing to avoid conflicts with important parts of wildlife life cycles will be stressed. Adequate standards for road and pad construction will be observed: case-by-case modifications will be necessary for cut slopes, berm size, run-off channelizations, slopes, etc.

Flat terrain for roads will diminish cut and fill and visual scars. Slopes over 30 percent will be avoided if possible. Natural drainage patterns of surface and shallow subsurface water will not be altered.

Stream crossings and diversions of flowing water will be kept to a minimum. Unstable soils will be avoided, and topsoil will be retained for use in revegetation and maintenance operations.

Construction patterns will be designed to conserve the "edge effect" and avoid critical or sensitive patches of vegetation. Single routes of approach to sites will be encouraged to minimize soil/vegetation modification and decrease the area affected.

Wherever feasible, snags and islands of vegetation will be coordinated with the surface managing agency.

Site inspection to appraise construction techniques will be necessary. Excessive dust generation, as evidenced by dust plumes and dust coverage of vegetation, will be mitigated by oiling or watering.

Buffer strips will be left around nests of uncommon raptorial birds. To coordinate mitigating measures the surface management agency will be consulted whenever nests are discovered. Similar protection will be extended to other wildlife species if population trends indicate the need.

Measures to reduce fire hazards include building fuel breaks between slash and surrounding areas and piling slash immediately after it is created. In some cases it will be necessary to designate additional areas where slash can be piled. The amount of slash on the ground can be minimized by burning and extending the burning season (night burning, wetting down the area, using extra men and equipment, etc.). Finally, prompt removal of merchantable logs and available cull material will be required to decrease the amount of combustible material on the ground.

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Revegetation programs will be instituted as soon as feasible to hasten natural soil stabilization. Revegetation will be coordinated with the surface management agency in order to choose the proper species composition, fertilizer, cultivation, etc.

Lease terms will require protection of both known archaeological sites and any sites that may be discovered during geothermal development. Development will be prohibited where archaeological or other special interest values of high significance are found.

The following measures will be taken to protect archaeological, historical, or other special interest values discovered:

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1. Prior to development the lessee will engage a qualified person (persons) acceptable to the land managing agency to survey the lands involved for sites and objects of cultural significance. The lessee will be required to salvage and protect any such objects found.
2. Upon discovery of cultural sites or objects, development will be halted pending determination of the significance of the discovery.
3. Use of existing roads will be encouraged to prevent inadvertent damage to archaeological resources.
4. Movement of equipment over known subsurface archaeological sites will be minimized. Necessary crossings will require placement of planking, earth mounding, and use of rubber-tipped equipment to minimize ground disturbance.
5. If archaeological areas of high use potential are discovered, planning will keep permanent scars and damage from nearby development out of view of visitors.
6. Federal agencies will consult with qualified archaeologists on methods of protecting high value sites for future use. All significant archaeological values will be protected by inclusion of stipulations in geothermal leases.

Road and drill pad construction—Planning should locate drill pads so that several will be close to or on one road. Since drill pads are large, general construction mitigations apply. Fire breaks should be incorporated into transportation routes.

Herbicidal control of unwanted vegetation—Herbicide use will be coordinated with the surface management agency. The choice of chemicals, application rates, restrictions, etc. will follow Federal, State, and local laws, regulations, and guidelines.

Detailed evaluation plans in POO

Possible discharge of drilling wastes, muds, geothermal fluids, etc.—Mitigation is best achieved by proper sump construction, maintenance, testing, and disposal. Unstable soils, landslides, surface water drainage pathways, steep topography, and other high hazard locations will be avoided. Sump walls must be strong enough to withstand minor earthquakes and moderate erosive forces of the weather. Sumps will have an impervious lining to prevent infiltration of the contents into adjacent surface, shallow and deep groundwater. Sumps will be of adequate capacity for drilling wastes and geothermal fluids which may require temporary storage. There will be no planned overflow into the sump. Chemical agents must be kept on hand to neutralize the pH or alter the chemistry of the liquids in the event of leakage.

No runoff into sump?

When a sump contains toxic mud, drilling wastes, or geothermal fluids, a strong fence will be built to prevent animals from reaching the sumps. During drilling and prior to disposal, detailed chemical analysis of all wastes, mud, and fluids will be made.

Contaminated water will only be discharged on the surface into holding ponds designed to safely contain such water. Contaminated water may be reinjected into the producing reservoir from which it was withdrawn or into other underground reservoirs to the extent such injection is consistent with applicable laws and regulations. In Idaho, geothermal fluids discharged into any underground waters have to be as high in quality as the receiving waters.

Toxic substances will be hauled to an appropriate dump site or left in the sump. Coordination with the surface managing agency, all local regulations, and the Environmental Protection Agency's guidelines will be required.

Wildlife dispersals to surrounding habitat—Wildlife dispersal will be lessened by minimizing the area affected, reducing associated impacts, and adhering to other mitigating measures.

Increased vehicular traffic—Proper planning of road locations will minimize vehicular traffic.

Increased noise—Diesel engines for drilling rigs and producing wells will be muffled. Drilling and construction will be timed to avoid periods of breeding and nesting of important wildlife species. For example, drilling and testing will be shut down during the breeding cycle of trumpeter swans, bald eagles, big game calving and fawning, etc. This will follow a very intensive biological survey on a site-by-site basis and coordination with the surface management agency. Additional muffling or other alternatives may be developed on a case-by-case basis. Proper planning to incorporate topography and vegetation will also attenuate increased noise levels. Operations will be kept away from residences, administrative sites, recreation areas, and wilderness access points.

Erosion—See General construction above. In addition filter strips of natural vegetation will be left between disturbed soil and drainage bottoms to aid in preventing stream sedimentation. Strip widths will be determined by the surface managing agencies.

Improper disposal of food-related garbage and other waste—Strict sanitation guidelines will be followd to prevent modifying nutrient cycles and wildlife feeding habits. In areas occupied by grizzly bears, bear-proof containers will be provided and accumulation of refuse will not be allowed.

Equipment maintenance (discharge of detergents, compounds, oil and gas, etc.)—Proper maintenance procedures will effectively mitigate any potential pollution. Any spills or discharges should immediately be cleaned up and the area inspected for damage to terrestrial and aquatic habitats. Further rehabilitation will be coordinated with the surface managing agency.

Blooie line operation—Mitigation for noise requires adequate muffling discussed above. Separators will remove foreign particles from the discharge.

Production testing—Mitigation for noise is discussed above. Barring accidents, no uncontrolled discharge of geothermal effluents will be permitted. Analysis of the effluent will be conducted as specified by the GRO's. Surface discharge will be considered only after a period of testing under full flow conditions. After the quality has been assured, it may be possible to use geothermal waters for beneficial purposes. If a danger of toxicity exists, testing will cease during periods of local weather anomolies (temperature inversions, heavy rain or snowfall, etc.). Hot liquid will be stored in the sump reservoir for evaporative loss to the atmosphere. Proper planning and timing of testing will utilize periods of atmospheric ventilation and avoid critical events in animal life cycles. Steam and gas venting to the atmosphere will be analyzed for constituents and appropriate control methods applied. Normally this will be removal of H_2S by scrubbing to reduce odor impacts.

Well blowout—Blowouts can be prevented by proper site selection, use of adequately strong casing material, and appropriate drilling procedures (maintaining proper drill mud temperatures, mud densities, etc.). Advanced planning for equipment and trained personnel can provide rapid control of blowouts. Blowout risk will be minimized by well monitoring practices designed to assure early detection of casing leaks and/or cement failures. Thorough and timely cleanup of blowout spills will lessen impacts.

Abandonment of wells—Unsuccessful wells will be abandoned and the site reclaimed. GRO order #3 covers the procedures required for well abandonment. In general, the hole must be filled with concrete and above-ground structures removed. Operations are of such limited nature that adherence to mitigation measures for increased noise, human presence, erosion, and general construction will minimize impacts. Landscape rehabilitation and revegetation plans will be closely coordinated with the surface management agency.

Increased human access—Public safety and security of geothermal facilities, as well as wildlife management considerations, may require closure or control of some roads and areas. Advanced planning on a site-by-site basis and coordination with Federal and State resource managing agencies are critical to effectively mitigate access impacts and to possibly derive benefits.

Man-made features—Facilities will be located and designed to blend into the forested background. Techniques for reducing contrast include designing buildings with low profiles and selecting paint colors that harmonize with trees, rocks, and other elements of the natural landscape. Use of existing roads and transmission lines wherever possible will help minimize impacts. New access roads will be less conspicuous if designed to follow the natural contour. The same principle will be applied to well and building sites. Irregularly shaped sites are less distracting to the eye and blend with their natural backdrops sooner upon abandonment. Clumps of vegetation will be left within cleared areas to break the contrast of geometrical structures with the irregular shapes of terrain and vegetation. Abandoned roads and the cleared area around wells and sumps will be scarified and replanted with native vegetation after completion of drilling and construction activities. Well pads may be reshaped to present a more natural appearance.

Visual quality standards described in Section II will be considered in any development of IPGA geothermal resources. Landscaping requirements necessary to protect visual resources will be formulated on a site-by-site basis as individual lease applications are reviewed. Geothermal development will be kept out of sight of all developed recreation sites.

CONSTRUCTION AND DEVELOPMENT

reveg. first rains

Construction of additional roads, drilling pads, sumps, buildings, etc.—See general construction and previous phases. Generally, complete mitigation is impossible for the modification of land, or for the physical occupation of the land by buildings. The measures available include: reducing noise, allaying dust, and choosing a time of construction to avoid interfering with the sensitive portion of animal life cycles, etc. Revegetation of all cleared areas and road cuts will begin at once, particularly on steep slopes. Runoff control structures will be designed and located so water can be directed onto energy-dissipating rocks or ground. In some cases it may be feasible to pond this water in an impermeable or slow draining basin so that local wildlife may obtain a water supply. Storage areas and parking lots will be consolidated and the number of roads minimized. A single large building will be preferred to a number of small buildings. A number of buildings will be clustered. Impediments to migration or critical social behavior of wildlife (elk migration corridors, breeding areas) will be particularly avoided.

Power plant and facilities—Mitigation measures discussed under general construction and previous phases apply here as well. Dewatering for excavation will not be allowed to adversely influence flows of nearby springs, streams, and/or wells. Disposal of pumped water will follow erosion mitigating measures, and flooding of land surfaces will not be allowed if damage to terrestrial and/or aquatic ecosystems is possible.

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Transmission lines—Mitigation for general construction impacts and previous phases also apply here. Proper planning of corridors will reduce impacts to wildlife. Transmission lines will utilize existing corridors or follow existing roads or clearings. If lines pass through habitat critical to important wildlife species, the right of way should be closed to access by humans during critical events in the species life cycle. Coordination with the surface managing agency is essential to this planning.

OK

Transmission line poles and towers should be no taller than necessary for support or for a minimum wire height. Power lines near waterfowl concentrations or local flyways will be avoided. Pole and insulator construction will be such that electrocution of raptors and other perching birds is prevented. Facilities such as transformers or switching stations should be situated in places where minimum erosion and wildlife disturbance will occur.

Pipelines—Mitigations for construction have already been discussed. Steam pipes will be located so that large animal migration or regular feeding is possible. Expansion loops may provide access if the loops are vertical. Pipe burial may be necessary in rare instances.

OK

Increased demand for social, health, education services and housing—The geothermal leasing program presents a problem because no one is certain exactly what or how much to prepare for. The key will be to continually update information on the progress of exploration and test drilling and to launch community preparation programs when exploration and test drilling change to construction and development.

OK

At lessee's expense, communities which are likely to receive population increases from geothermal leasing will be given detailed plans for development timing and changes in employment. These should be updated frequently and the actual number and residential location of employees monitored to verify predictions.

A massive boom in development should be avoided by slowing the employment increase when communities are in danger of being overwhelmed.

OK

The general relationship between local government officials and lessees should be worked out before leases are granted. The lease should contain wording to reinforce this relationship. It is in the long range interest of both to be in a cooperative rather than adversary position.

OPERATION

none whatsoever

Power plant—Generally, operation of a geothermal field increases continuous noise, discharge of geothermal fluids, operation of machinery, construction, human activity—all of the characteristics of an industrial complex. Mitigation has been discussed under previous phases. Improving technology, increasing efficiency of power plants, and using excess heat for non-electrical purposes (space heating, greenhouses, etc.) could further minimize impacts such as thermal pollution. Extraction of groundwater for cooling and/or make-up water will not be allowed to lessen flows to nearby springs, streams, and/or wells. Water impounded, diverted, or withdrawn by pumping will not be allowed to interfere with downstream uses.

Cooling towers, transmission lines and pipelines—Mitigation is discussed under previous sections. Human access will be strictly controlled to prevent human-wildlife conflicts. Coordination with the surface management agencies is critical.

OK

Reinjection—Contamination and/or modification of surface and groundwater aquifers may be avoided by casing the injection well to a depth that will prevent penetration of an aquifer. Reinjection will not be conducted in zones where faults have been detected, and where upward leakage of injected fluids will cause movement of unstable soil and earth materials.

OK

Release of gases and vapors—If discharged gases and/or vapors produce acid rain, monitoring of terrestrial and aquatic ecosystems will be required to determine changes and provide mitigating measures. Shutdown of operations will be required if satisfactory mitigation measures are not available.

Increased demand for social, health, educational services ~~and housing~~—Facilities developed during the construction and development phase will be more than adequate to meet the needs of geothermal employees and families during operation.

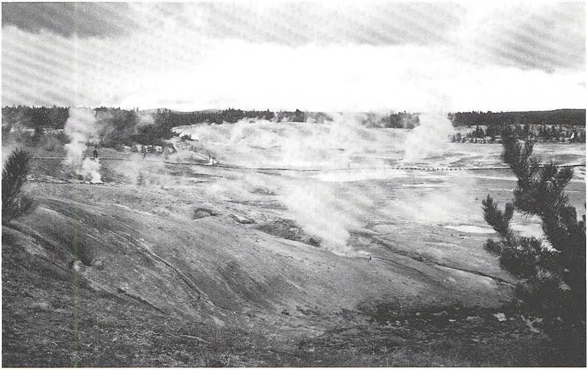
YELLOWSTONE NATIONAL PARK

Because no existing data identifies a connection between Yellowstone National Park geothermal features and geothermal features outside the Park, thermal development outside the Park must be tied to a monitoring scheme inside the Park. The following monitoring program will be required if a developable geothermal resource is found within five airline miles of the Park boundary.

1. Stream gauging stations will be established on Boundary Creek and the Bechler River below areas of thermal output to monitor discharge and chloride concentrations.
2. Place a deep, narrow hole monitoring well between the major geyser basins along the Firehole River and the area of commercial development, approximately two miles inside the Park boundary.
3. Reactivate the 1967 U.S. Geological Survey's Black Sand Basin research well Y-1 near the Upper Geyser Basin as a monitoring well. If possible, extend this well down into the same reservoir or aquifer that the commercial wells use. Periodically check pressure, temperature and chloride concentrations to determine if there is any influence from extractions outside the Park.

All geothermal fluids extracted and use in this area adjacent to Yellowstone National Park will be reinjected into the reservoir from which it was extracted to minimize loss of reservoir pressure.

If extraction of geothermal fluids from outside the Park significantly influences pressure, chloride concentration, and temperature, operations will be suspended until the influences can be eliminated. If the influences cannot be eliminated, the operation(s) will be terminated.



Yellowstone National Park geothermal features must be considered.

VIII. CONSULTATION WITH OTHERS

The need to prepare an environmental statement for geothermal leasing in the Island Park area was agreed upon at an interagency meeting held in Boise, Idaho on May 7, 1975. Representatives from the U.S. Geological Survey, Bureau of Land Management, U.S. Forest Service, U.S. Fish and Wildlife Service and National Park Service attended the meeting and discussed consequences of a geothermal leasing program in the Island Park area. It was agreed at this meeting that the Targhee National Forest would serve as the lead agency for this interagency effort.

Another interagency meeting was held in Idaho Falls in January 1977. This meeting established commitments and level of involvement for each of the participating agencies. The following agencies agreed to provide specific information and involvement into the environmental statement effort:

- U.S. Forest Service
  - Gallatin National Forest
  - Targhee National Forest (lead agency)
- Bureau of Land Management
  - Idaho Falls District
- National Park Service
  - Yellowstone National Park
- U.S. Fish and Wildlife Service
  - Ecological Services
- U.S. Geological Survey
  - Conservation Division
  - Geologic Division
  - Water Resources Division

Each participating agency has provided personnel to comprise the multi-disciplinary study team. These team members have served as key representatives for their agency.

Public involvement has been a continuous activity. It includes the giving and receiving of information relevant to geothermal development in the area of consideration. The following is the sequence of public involvement in the environmental statement process to date:

Activity	When
Announced intent to prepare an environmental statement and identified who was involved (News Media)	January 1977
Distributed information brochure (brief) with response form for comments or concerns. Approximately 800 copies distributed	May-August 1977
Mailed notification of public involvement workshop in Rexburg, Idaho, March 18, 1978. Approximately 700 copies distributed	February 1978
Island Park Geothermal Workshop held at Madison Junior High School, Rexburg, Idaho	March 18, 1978
Informal contacts with various public segments, state agency representatives, and congressional delegates	Concurrently

Many Federal, State, and local agencies not already mentioned have provided consultation and/or contribution to the preparation of this statement. They include:

FEDERAL

Environmental Protection Agency
Department of Energy
National Oceanic and Atmospheric Administration
Advisory Council on Historic Preservation
Department of the Interior

- Bureau of Reclamation
- Bonneville Power Administration
- Bureau of Mines

STATE AND LOCAL

IDAHO

Fish and Game Department
Department of Health and Welfare, Division of Environment
Department of Water Resources
Department of Parks and Recreation
Department of Lands
State Archaeologist
Public Utilities Commission
Division of Budget, Policy Planning and Coordination
Historic Preservation Officer
Office of Energy
Attorney General's Office

MONTANA

Energy Office
Department of Health and Environmental Science
Historical Society
Department of Natural Resources and Conservation
Bureau of Mines and Geology

WYOMING

Game and Fish Department
Geological Survey

INFORMATION RECEIVED UNDER CONTRACT WITH CONSULTING FIRMS

EDAW, Inc. .... Fort Collins, CO
Western Environmental Research Associates .... Pocatello, ID

Many interested groups and individuals have provided consultation. They include:

GROUPS

Fall River Rural Electric Cooperative, Inc. .... Ashton, ID
Forsgren, Perkins & Associates .... Rexburg, ID
Idaho Conservation League .... Boise, ID
Idaho Environmental Council .... Idaho Falls, ID
Outdoors Unlimited, Inc.—Sawtelle Chapter .... St. Anthony, ID
The Montana Wilderness Association .... Helena, MT
Idaho Geothermal Corporation .... St. Anthony, ID
Occidental Geothermal, Inc. .... Bakersfield, CA
Union Oil of California .... Santa Rosa, CA
Audubon Society—Snake River Chapter .... Idaho Falls, ID

INDIVIDUALS

Ralph Maughan .... Pocatello, ID
Ray Breuninger .... Helena, MT
Marian Boulter .... Rexburg, ID
Keith E. Brown .... Canyon Creek, MT
Craig Carver .... Denver, CO
Eddie Chew .... Idaho Falls, ID
Phil Choate .... Rexburg, ID
Vernon Christoffersen .... Tetonia, ID
Eugene V. Ciancanelli .... San Diego, CA
Gary L. Davidson .... Idaho Falls, ID
Mark Dublin .... Idaho Falls, ID
Sandy Enyeart .... Idaho Falls, ID
Beth Gorringe .... St. Anthony, ID
Russell Hillman .... St. Anthony, ID
Roger D. Hoggan .... Rexburg, ID
Klem K. Kennedy .... Idaho Falls, ID
Steven Knapp .... Ashton, ID

Michael McSorely . . . . . Pocatello, ID
William G. Miller . . . . . St. Anthony, ID
C.F. Murer . . . . . Denver, CO
Deborah Parrott . . . . . Victor, ID
Ralph V. Pehrson . . . . . Boise, ID
Chris H. Peterson . . . . . Idaho Falls, ID
Robert Ruud . . . . . St. Anthony, ID
Fred Schmidt . . . . . Butte, MT
Glan Sharp . . . . . Squirrel, ID
Samuel E. Shepley . . . . . Idaho Falls, ID
P.A. Smith . . . . . San Francisco, CA
Bob Stenner . . . . . Pocatello, ID
Jacquelyn Sullivan . . . . . Idaho Falls, ID
Jack Thomas . . . . . Island Park, ID
Mrs. Jack Thomas . . . . . Island Park, ID
Ryan Tibbitts . . . . . Rexburg, ID
Gerald Vaughan . . . . . Bakersfield, CA
Jennifer Whipple . . . . . Arcata, CA
Calvin H. Wickham . . . . . Ashton, ID
Ed Williams . . . . . Rexburg, ID
Charlie Woodward . . . . . Victor, ID
A.D. Zierold . . . . . Boise, ID

LETTERS OF CONSULTATION

Two letters of consultation were received and are included for reference.

IDAHO STATE HISTORICAL SOCIETY

610 NORTH JULIA DAVIS DRIVE   BOISE, IDAHO 83706

January 17, 1977

STATE MUSEUM

Gentlemen:

Thank you for allowing review of your "Study Plan for Geothermal Environmental Statement - Yellowstone-Island Park Known Geothermal Resource Areas." Our concern is with the archaeological and historic properties in the area.

Some preliminary archaeological surveys have been conducted along Henry's Fork near Island Park Village. The results of the preliminary surveys indicate that important archaeological sites dating from 10,000 years B.P. to historic Indian and fur trading villages occur in the area.

Hence, we recommend that for each lease application for geothermal development that archaeological and historical surveys be conducted as soon as weather permits. The results of these surveys should be included in the draft environmental impact statement. These surveys would allow the identification of the impacts from geothermal projects to important non-renewable archaeological and historical resources. The draft EIS can then detail the impacts to these resources and suggest various proposals to mitigate these impacts. Another advantage of immediate archaeological inventory is that the cost of mitigation can then be included in the cost analysis of the geothermal development.

If we can be of help in designing these surveys please contact us.

Sincerely,

Thomas J. Green

Thomas J. Green
Acting State Archaeologist
State Historic Preservation Office

United States Department of the Interior
FISH AND WILDLIFE SERVICE

MAILING ADDRESS:
Post Office Box 25486
Denver Federal Center
Denver, Colorado 80225

STREET LOCATION:
10597 West Sixth Avenue
Lakewood, Colorado
Across From Federal Center

IN REPLY REFER TO:

FA/SE/Coop.--Federal--FS
Island Park Geothermal Leasing Area JUL 27 1978

Mr. Vern Hamre
Regional Forester
U.S. Forest Service
324 25th Street
Ogden, UT 84401

Dear Mr. Hamre:

This is our official response to your request of June 6, 1978, for formal consultation on the effects of geothermal leasing within the Targhee and Gallatin National Forests on the threatened grizzly bear. We have conducted a threshold examination as prescribed in the Interagency Cooperation Regulations of January 4, 1978.

The impacts of geothermal leasing in the Island Park Geothermal Area (IPGA) will increase as the various phases of exploration progress towards full development of the geothermal resource, if one is found and determined to be commercially valuable for development. Accordingly, our biological opinion is based on the accumulative effects of the sequential phases of exploration and development.

It is our biological opinion that:

(1) Geothermal leasing in the IPGA outside the boundaries of the proposed critical habitat for the grizzly (Federal Register Vol. 41, No. 215), is not likely to jeopardize the continued existence of the grizzly bear or destroy or adversely modify its habitat.

(2) Geothermal leasing within the proposed critical habitat (Federal Register Vol. 4, No. 215) as it encompasses all associated activities of the casual use phase and exploratory phase up to but not including deep-well drilling is not likely to jeopardize the continued existence of the grizzly or destroy or adversely modify its habitat.

(3) Insufficient information exists to provide a biological opinion on the advanced phases of geothermal exploration (deep-well drilling

and subsequent field development) that may occur within proposed grizzly bear critical habitat, should a productive geothermal reservoir be located. Our opinion is based on the following considerations.

Although most of the IPGA is within the general distribution of the grizzly bear in the Yellowstone ecosystem, sightings of grizzlies in areas outside the proposed critical habitat are infrequent. The proposed U.S. Fish and Wildlife Service critical habitat encompasses those areas considered by the Forest Service to be essential to the grizzly as well as areas which may be needed for recovery. Thus leasing and its associated activities outside the proposed critical habitat area should not adversely affect the grizzly bear.

Inside the proposed critical habitat area, impacts of geothermal leasing may increase with successive exploration phases until a threshold is reached beyond which adverse modification of the habitat may occur. Activities of the casual use phase and early stages of the exploration phase (activities up through the drilling of shallow temperature gradient holes) should not adversely affect the grizzly. Activities up to the point of deep-well drilling generally involve small crews with vehicular activity restricted to established roads and trails and are of short duration (one to two weeks). The environmental impact of drill temperature gradient holes (holes usually less than 500 feet) is only slightly greater than ground reconnaissance and generally requires no site preparation.

The impacts of deep-well drilling and subsequent geothermal development may have adverse effects on the grizzly. Wells are currently drilled to a depth of about 10,000 feet and involve large, highly-engineered drill sites. One to five wells may be expected for finding and testing geothermal fluids. Existing access roads may be improved to accommodate the heavy equipment. Since existing roads often approach chosen sites within one to two miles, and exploration wells are normally one quarter mile to one half mile apart, about three to five miles of new road may be necessary for one exploratory effort of deep-well drilling. Each of the drilling operations will require a level drill pad of about one to three acres and a mud sump (varying from less than one hundred to several thousand square meters on the surface down to a depth of from five to ten feet) for temporary storage of drilling mud and possibly storage of geothermal resource effluent. A crew of 20 to 24 is generally required for drilling operations. Should the exploratory wells prove productive and valuable for commercial development, the full impacts of plant facilities, feeder pipelines, power transmission lines, additional roads and human occupation would be realized.

Without a knowledge of where productive geothermal reservoirs lie, should any exist in the IPGA, and where deep-well drilling is anticipated, a biological opinion on deep-well drilling and full field

development within proposed critical habitat cannot be made. Should an operator, after evaluating the results from shallow temperature gradient holes, decide that deep well drilling is feasible he would submit a Plan of Operation and the appropriate Notice of Intent to conduct deep well exploration operations. At this point formal consultation should be reinitiated, a site specific analysis made, and a biological opinion given. While advanced geothermal exploration may or may not be detrimental to the grizzly, early phases of exploration within proposed critical habitat are recognized as being valuable in the assessment of the geothermal resource potential in the IPGA. It is also recognized that of all the leased land on which exploration may be initiated only those relatively few leases having the greatest potential are likely to undergo development, and exploration will leave no lasting environmental effects on the majority of those leases which do not reach the development stage.

Leasing alternatives as outlined in the draft Island Park Geothermal Environmental Impact Statement present varying degrees of impacts to the grizzly. Alternative 3 would have the least short-range impact (excluding Alternative 1-No Leasing). Essential grizzly habitat as defined and identified by the Forest Service is either removed from leasing or deferred as well as portions of the proposed critical habitat not included in the Forest Service designation.

Alternative 5 is similar to Alternative 3 with the exception that areas deferred from leasing in Alternative 3 would be leased with surface occupancy restrictions. Activities in areas with surface occupancy restrictions under this alternative are consistent with our opinion (allows exploration activities up to but not including deep well drilling).

Alternative 4 invokes a "true" non-surface occupancy restriction which includes all Forest Service delineated essential habitat. However, directional drilling from the outside perimeter of these areas would affect proposed critical habitat. Areas of particular concern would be south and southeast boundaries of the IPGA below Yellowstone National Park. Alternatives 2 and 6 are the least desirable. In all alternatives, deep-well drilling and subsequent development of the geothermal resource within proposed critical habitat would require reinitiation of formal consultation.

This completes the formal consultation process on geothermal leasing in the IPGA. We appreciate your cooperation and interest in meeting our joint consultation responsibilities.

Sincerely yours,

Marvin L. Duncan

Regional Director

IX. INDEX

APPENDIX A. CHEMICAL ANALYSES OF THERMAL SPRINGS NEAR THE ISLAND PARK GEOTHERMAL AREA
(mg/l unless noted)

Spring name and/or location (all in Idaho except one) / Parameter	Ashton Hot Spring 9N-42E-23 dac	Unnamed spring near Coyote Creek, Wyoming 47N-118W-28	Big Springs 14N-44E-34 bbb	Warm River Spring 10N-44E-10 aba	Unnamed spring near mouth of Warm River 9N-43E-15 ddc	Unnamed spring near Sawmill Creek 9N-45E-6 ddd
Date Sampled	9/6/77	9/20/77	9/8/77	9/21/77	9/21/77	9/21/77
Discharge, gal/min.	2	1	92,200	90,000	2	8
Water Temp. °C	39.5	17.0	11.8	10.3	16.3	13.5
As, ug/l	13	0	—	1	8	1
HCO_3	87	92	73	48	120	150
B, ug/l	40	10	60	120	40	4
Ca	1.4	22	7.3	6.0	20	38
Cl	3.3	1.2	3.2	6.9	5.2	1.8
F	2.4	2.0	3.6	2.2	1.4	1.4
Hardness, total	4	66	21	21	65	120
Fe, ug/l	40	20	—	30	60	20
Li, ug/l	50	30	—	60	80	20
Mg	0.1	2.8	0.7	1.4	3.7	7.1
Mn, ug/l	10	0	—	0	0	0
NO_2 & NO_3 as N dissolved	0.26	0.14	0.03	0.21	0.85	0.15
pH (field)	7.9	8.2	6.7	6.8	6.8	6.6
P total as p	0.04	0.01	0.00	0.11	0.03	0.01
K	1.6	1.1	3.0	1.4	1.2	1.5
TDS	116	123	117	91	163	177
SiO_2	22	37	46	32	39	43
Na	37	9.3	15	14	24	7.4
SO_4^2	3.9	1.2	2.2	1.9	4.9	1.9
Zn, ug/l	10	0	—	20	0	0

Source: Unpublished records of the U.S. Geological Survey

APPENDIX B. CHEMICAL ANALYSES OF SELECTED WELLS AND SPRINGS (mg/l unless noted)

Well location, Spring name and/or location (locations by township, range section) / Chemical Parameter	MONTANA: Unnamed spring source of the South Fork Madison River 14S-5E-19 aba	MONTANA: Black Sand Spring 13S-5E-31	MONTANA: Well in West Yellowstone 13S-5E-34	IDAHO: Well near Continental Divide 15N-43E-13 bca	IDAHO: Well, north of and near north edge of caldera 13N-43E-15 adc	IDAHO: Well inside of and north of center of caldera 12N-44E-20 adb	IDAHO: Osborne Springs 11N-42E-5 bdc
Date of Sampling	9/7/77	9/7/77	9/7/77	9/8/77	9/8/77	7/24/75	6/8/74
Water Temp °C	4.8	9.5	8.3	12.3	8.5	7.5	5.5
Geohydrologic unit	rhyolitic flows and tuffs	obsidian sands and rhyolitic flows	obsidian sand	alluvial and glacial materials	rhyolitic flows and tuffs	basalt	basalt
pH (field)	6.6	6.8	7.3	6.9	6.7	6.9	7.3
HCO_3	18	36	44	220	53	46	59
B, ug/l	6	70	60	—	9	—	—
Ca	5.2	5.9	5.7	50	11	7.4	7.6
Cl	0.5	4.7	4.4	1.6	1.0	0.7	1.5
F	1.4	3.8	3.8	0.1	0.5	1.4	1.3
Hardness, total	17	18	18	190	39	40	—
Mg	1.0	0.8	1.0	15	2.7	5.2	3.0
NO_2 and NO_3 as N dissolved	0.01	0.01	0.01	0.00	0.02	0.63	0.05
K	1.5	2.0	1.9	1.0	1.6	1.2	2.1
TDS	46	85	88	200	81	86	—
SiO_2	24	37	33	14	30	37	—
Na	2.2	12	15	1.7	4.3	4.8	5.3
SO_4^2	0.9	0.9	0.9	4.4	3.0	5.0	2.9

Sources: 1974 and 1975 data from R.L. Whitehead, 1978; other data from unpublished records of the U.S. Geological Survey.

APPENDIX C. CHEMICAL ANALYSES OF HOT WATER FROM SELECTED GEYSER BASINS[1] IN YELLOWSTONE NATIONAL PARK
(mg/l; Tr = Trace)

	Lower Geyser Basin (24 analyses from 9 springs)	Midway Geyser Basin (7 analyses from 1 spring)	Upper Geyser Basin (23 analyses from 6 springs)	Shoshone Geyser Basin (2 analyses from 2 springs)
Temperature ° C	65-95	63-92	70-boiling	92, 93
pH (lab)	6.8-9.23	7.5-8.45	3.45-9.78	—
SiO_2 (lab)	175-412	221-303	128-456	280-305
Al	0-2.1	<0.1-1.2	0-7.9	0.3-4
Fe	0-2	0-1.8	0-1.2	Tr-<0.1
Ca	Tr-18	<0.1-3	0-9	Tr-1.0
Mg	0-2.3	0-2.2	0-1.4	0.9 (one analysis)
Na	85-366	382-419	37-460	250-322
K	9.5-21	12-33	6.9-40	13-23.5
Li	0.5-3.8	2.0-2.8	0.16-7.0	0.9-1.2
NH_4	0.5 (one analysis)	0.01 (one analysis)	0.01,0.21 (2 analyses)	—
HCO_3	136-310	527-562	0-621	445 (one analysis)
CO_3	0-106	0-20	0-103	—
SO_4	14-68	18-34	8-231	35-48
Cl	52-370	270-290	1-466	125-200
F	10-25	18-24	0-35	16, 23
B	0.6-5.1	2.5-5.0	0.02-7.6	1.8-4.6
As	0-3.6	2.0-2.3	0.45-2.5	0.53 (one analysis)

[1] Basins are in a north-south band roughly 12 miles from the east boundary of the IPGA.

Source: Rowe, J.J., R.O. Fournier, and G.W. Morey, 1973.

APPENDIX D. CHEMICAL ANALYSES OF HENRYS FORK TRIBUTARIES[1]
(mg/l unless noted)

	Buffalo River	Warm River	Robinson Creek	Conant Creek[2]
Date sampled	9/9/77	9/19/77	9/19/77	9/29/77
Water Temp °C	8.3	11.8	11.3	8.0
DO	8.0	—	—	8.0
pH (field)	7.1	8.6	8.8	7.9
HCO_3	83	56	74	84
B, ug/l	60	110	160	—
Ca	6.4	10	12	20
Cl	3.0	6.0	8.2	0.9
F	2.7	2.3	2.2	0.5
Hardness, total	21	32	42	69
Mg	1.1	1.7	2.8	4.6
NO_2 and NO_3 as N dissolved	0.07	0.08	0.08	0.06
P total as P	0.00	0.01	0.00	0.03
K	2.6	1.6	2.1	0.9
TDS	115	102	120	95
SiO_2	40	36	39	21
Na	16	15	15	3.4
SO_4	2.2	1.2	1.6	1.6

[1] These are in Wyoming and Idaho; (refer to map 5); samples taken at or near mouth of each stream
[2] Sampled where Conant Creek leaves the Targhee National Forest, roughly 14 miles from mouth

Source: Unpublished records of the U.S. Geological Survey

APPENDIX E. WILDLIFE SPECIES ORIENTATION TO HABITATS

Species	Seasonal occurrence[1]	Abundance[2]	Number of habitats & successional stages used for: Reproduction	Feeding	Total number of habitats species uses
Downy Woodpecker	P	C	19	22	22
*Black-backed 3-toed Woodpecker	M	R	14	16	16
*Northern 3-toed Woodpecker	P	U	13	15	15
Eastern Kingbird	S	C	18	19	19
Western Kingbird	S	C	15	17	17
Say's Phoebe	S	C	6	6	8
Western Tanager	S	C	19	21	21
Hammond Flycatcher	S	C	14	19	19
Dusky Flycatcher	S	C	14	18	18
Western Wood Pee-wee	S	C	13	18	18
Olive-sided Flycatcher	P	C	11	22	22
Horned Lark	S	C	1	7	7
Violet-green Swallow	S	C	17	18	21
Tree Swallow	S	C	18	21	24
Bank Swallow	S	C	3	17	17
Rough-winged Swallow	S	C	4	16	17
Barn Swallow	S	C	13	16	16
Cliff Swallow	S	C	4	21	21
Gray Jay	P	C	14	19	19
Stellar's Jay	P	C	13	20	20
Black-billed Magpie	P	C	15	21	21
Common Raven	P	C	15	22	23
Common Crow	P	C	15	19	20
Clark's Nutcracker	P	C	11	16	16
Black-capped Chickadee	P	C	20	25	25
Mountain Chickadee	P	C	19	21	21
White-breasted Nuthatch	P	C	13	15	15
Red-breasted Nuthatch	P	C	16	18	18
Brown Creeper	P	C	12	14	14
Dipper	P	C	18	12	20
House Wren	S	C	15	15	18
Long-billed Marsh Wren	S	C	3	3	3
Canyon Wren	P	C	8	14	15
Rock Wren	S	C	8	10	11
Gray Catbird	S	U	15	16	16
American Robin	S	C	23	26	26
Hermitt Thrush	S	C	13	18	18
Mountain Bluebird	S	C	16	21	26
Townsend's Solitaire	P	C	15	19	20
Golden-crowned Kinglet	P	C	8	14	14
Ruby-crowned Kinglet	P	C	12	16	16
Cedar Waxwing	S	C	13	14	14
*Loggerhead Shrike	S	U	2	10	10
Starling	P	C	8	8	10
Solitary Vireo	S	C	16	20	20
*Warbling Vireo	S	R	10	11	11
Orange-crowned Warbler	S	R	12	14	14
*Yellow Warbler	S	C	5	5	5
Yellow-rumped Warbler	S	C	18	23	23
MacGillvary's Warbler	S	C	14	14	14
Common Yellowthroat	S	C	5	9	9
*Yellow-breasted Chat	S	U	5	16	16
Wilson's Warbler	S	C	7	7	7
House Sparrow	P	C	5	6	7

Species	Seasonal occurrence[1]	Abundance[2]	Number of habitats & successional stages used for: Reproduction	Feeding	Total number of habitats species uses
Western Meadowlark	S	C	6	7	7
Yellow-headed Blackbird	S	C	2	6	6
Red-winged Blackbird	S	C	5	7	7
Northern Oriole	S	C	13	14	14
Brewer's Blackbird	S	C	13	15	15
Brown-headed Cowbird	S	C	19	21	21
Lazuli Bunting	S	U	14	16	16
Evening Grosbeak	P	C	14	19	19
Cassin's Finch	S	C	11	19	19
House Finch	P	C	15	19	19
Pine Grosbeak	P	C	10	16	16
Black Rosy Finch	P	U	6	16	17
Pine Siskin	P	C	14	22	22
American Goldfinch	P	C	15	19	19
Red Crosbill	P	C	12	16	16
Green-tailed Towhee	M	C	5	11	11
Rufous-sided Towhee	S	U	18	19	19
Savannah Sparrow	S	C	1	1	1
*Vesper Sparrow	S	C	4	4	4
Sage Sparrow	S	U	1	6	6
Dark-eyed Junco	P	C	17	18	18
Chipping Sparrow	S	C	20	23	23
Brewer's Sparrow	S	C	2	5	5
White-crowned Sparrow	S	C	16	23	24
Fox Sparrow	S	C	12	17	17
Lincoln's Sparrow	S	C	5	11	11
Song Sparrow	P	C	15	18	18
MAMMALS					
Masked shrew	P	U	13	13	13
Vagrant shrew	P	C	24	24	24
Northern water shrew	P	U	18	19	19
Little brown myotis	S	C	14	22	23
Yuma myotis	S	U	4	6	6
Long-eared myotis	S	C	10	18	19
*Long-legged myotis	S	C	10	18	19
Small-footed myotis	S	C	5	8	9
*Fringed myotis	S	U	13	15	16
*California myotis	S	U	17	13	20
Silver-haired bat	S	C	10	18	19
Big brown bat	S	C	12	23	25
Hoary bat	S	C	15	23	26
*Western big-eared bat	S	C	4	5	6
Pika	P	C	3	5	5
Mountain Cottontail	P	C	8	9	10
Snowshoe hare	P	C	17	15	18
White-tailed jackrabbit	P	C	2	4	4
Least chipmunk	P	C	18	19	19
Yellowpine chipmunk	P	U	23	25	25
Yellow-bellied marmot	P	C	11	13	13
Richardson's ground squirrel	P	C	1	2	2
*Uinta ground squirrel	P	U	4	5	5
Columbian ground squirrel	P	U	16	17	17
Mantled ground squirrel	P	C	19	24	24
Red squirrel	P	C	16	18	18

APPENDIX E. WILDLIFE SPECIES ORIENTATION TO HABITATS

Species	Seasonal occurrence[1]	Abundance[2]	Number of habitats & successional stages used for: Reproduction	Feeding	Total number of habitats species uses
*Golden Eagle	P	R	14	29	29
*Bald Eagle	P	U	16	23	23
*Marsh Hawk	P	U	7	9	10
*Osprey	S	C	17	2	17
*Prairie Falcon	S	U	2	6	7
*Peregrine Falcon	M	R	0	17	17
*Merlin	S	U	14	23	23
*American Kestrel	P	C	19	22	25
Blue Grouse	P	C	17	25	25
Ruffed Grouse	P	C	17	20	20
*Sharp-tailed Grouse	P	R	7	8	8
*Sage Grouse	S	C	1	6	6
Sandhill Crane	S	C	3	14	14
Virginia Rail	S	U	3	11	11
Sora	S	C	3	10	10
American Coot	P	C	5	13	13
Killdeer	S	C	5	16	16
*Mountain Plover	M	R	2	2	2
Common Snipe	S	C	5	14	14
Long-billed Curlew	S	U	1	7	7
Spotted Sandpiper	S	C	5	11	11
Solitary Sandpiper	M	R	5	15	15
Greater Yellowlegs	M	U	0	7	7
Willet	S	C	3	12	12
American Avocet	S	C	5	12	12
Wilson's Phalarope	S	C	2	3	3
California Gull	S	C	3	11	11
Ring-billed Gull	S	C	3	16	16
Caspian Tern	M	R	0	1	1
Rock Dove	P	C	12	13	15
Mourning Dove	P	C	15	13	17
*Barn Owl	P	U	12	14	17
*Screech Owl	P	U	19	24	24
Flammulated Owl	P	R	14	13	16
Great Horned Owl	P	C	15	22	24
*Snowy Owl	W	R	0	8	8
*Pygmy Owl	P	R	16	24	24
*Burrowing Owl	S	U	2	4	4
*Barred Owl	M	U	15	19	19
*Long-eared Owl	S	U	18	23	23
*Short-eared Owl	P	U	9	13	14
*Saw-whet Owl	P	R	17	20	20
*Great Gray Owl	S	R	6	6	9
Gyrfalcon	W	R	0	7	7
Poor-will	S	C	2	7	7
Common Nighthawk	S	C	17	21	22
Calliope Hummingbird	S	C	11	17	18
Broad-tailed Hummingbird	M	R	10	12	12
Belted Kingfisher	P	C	14	16	17
Common Flicker	P	C	15	21	21
*Lewis Woodpecker	S	C	18	21	21
Yellow-bellied Sapsucker	S	C	15	15	15
*Williamson's Sapsucker	S	U	12	12	12
*Hairy Woodpecker	P	C	16	19	19

APPENDIX E. WILDLIFE SPECIES ORIENTATION TO HABITATS

Species	Seasonal occurrence[1]	Abundance[2]	Number of habitats & successional stages used for: Reproduction	Feeding	Total number of habitats species uses
AMPHIBIANS					
Tiger Salamander	P	C	16	16	17
Western Toad	P	U	9	9	9
Chorus Frog	P	C	6	6	6
Spotted Frog	P	C	15	15	15
Leopard Frog	P	C	19	19	19
REPTILES					
Sagebrush Lizard	P	U	7	8	9
Western Skink	P	U	18	18	18
Northern Aligator Lizard	P	U	10	11	12
*Rubber Boa[3]	P	U	16	19	21
Racer	P	C	17	20	20
Gopher Snake	P	C	25	25	25
Common Garter Snake	P	C	22	23	23
Western Garter Snake	P	C	11	16	16
BIRDS					
Common Loon	M	R	9	13	13
Eared Grebe	S	C	4	4	4
*Western Grebe	M	C	9	13	13
Great Blue Heron	S	C	14	16	19
*Black-crowned Night Heron	S	U	5	5	5
*American Bittern	S	C	2	4	4
Whistling Swan	M	R	0	16	16
*Trumpeter Swan	P	C	16	19	19
Canada Goose	P	C	6	11	12
Snow Goose	M	R	0	8	8
Mallard	S	C	15	22	23
Gadwall	S	C	3	15	15
Pintail	S	C	5	16	16
Green-winged Teal	S	C	4	14	14
Blue-winged Teal	S	C	2	12	12
Cinnamon Teal	S	C	3	10	10
American Widgeon (Baldpate)	S	C	7	15	15
Northern Shoveler	S	C	3	15	15
Readhead	S	C	3	16	16
Ring-necked Duck	S	U	5	21	21
*Canvasback	M	C	1	11	11
Lesser Scaup	S	C	7	19	19
Common Goldeneye	M	U	17	17	18
Bufflehead	S	U	13	15	17
Ruddy Duck	S	U	10	18	18
Common Merganser	P	U	17	17	20
Turkey Vulture	S	C	16	25	25
*Goshawk	P	U	11	21	21
*Sharp-shinned Hawk	P	U	16	23	23
*Cooper's Hawk	S	U	15	24	24
Red-tailed Hawk	P	C	17	27	27
*Swainson's Hawk	S	U	16	21	21
Rough-legged Hawk	W	C	0	4	4
*Ferruginous Hawk	S	R	1	4	5

[1], [2], [3] See footnotes at end of Appendix

APPENDIX E. WILDLIFE SPECIES ORIENTATION TO HABITATS

Species	Seasonal occurrence[1]	Abundance[2]	Number of habitats & successional stages used for: Reproduction	Feeding	Total number of habitats species uses
Northern flying squirrel	P	U	13	12	13
Northern pocket gopher	P	C	24	24	24
Beaver	P	C	5	23	24
Deer mouse	P	C	31	31	31
Busy-tailed woodrat	P	C	22	23	24
Boreal red-backed vole	P	C	12	12	12
Mountain vole	P	U	20	20	20
Meadow vole	P	C	7	7	7
Long-tailed vole	P	C	21	20	21
Sagebrush vole	P	U	2	2	2
Muskrat	P	C	7	10	10
Western jumping mouse	P	C	16	17	17
Porcupine	P	C	19	23	25
Coyote	P	C	25	30	30
Red fox	P	U	18	23	24
*Northern Rocky Mountain wolf	P	R	?	26	27
Black bear	P	C	17	31	31
*Grizzly bear	P	R	18	27	27
Raccoon	P	U	19	23	24
Marten	P	U	9	16	16
*Fisher	P	R	15	20	21
Short-tailed weasel	P	C	13	16	16
Long-tailed weasel	P	C	30	30	30
Mink	P	C	25	26	26
*Wolverine	P	R	9	17	17
Badger	P	C	13	16	16
Striped skunk	P	C	16	18	18
River otter	P	U	21	21	21
Cougar	P	R	17	25	26
*Canada lynx	P	R	12	19	19
*Bobcat	P	C	21	25	26
Elk (Wapiti)	P	C	16	24	24
Mule deer	P	C	15	23	23
Pronghorn	S	U	3	5	5
Moose	P	C	11	25	25

FOOTNOTES

[1] P = permanent resident; S = summer resident; M = migrant; W = winter resident.

[2] C = common—occurs in many localities in large numbers
U = uncommon—occurs in several localities in small numbers
R = rare—highly localized; restricted by scarcity of habitat and/or low numbers.

[3] * = species of special interest and concern as listed by the U.S. Department of the Interior (1973), Wyoming Game and Fish Department (1978), Montana Department of Game and Fish (1978), Idaho Department of Fish and Game (1978), and the National Audubon Society (1977).

APPENDIX F. MIGRANT AND ACCIDENTALLY OCCURRING WILDLIFE SPECIES ON THE ISLAND PARK GEOTHERMAL AREA.

Arctic Loon
Red-necked Grebe
Pied-billed Grebe
White Pelican
Double-breasted Cormorant
Mute Swan
White-fronted Goose
Ross' Goose
Greater Scaup
Barrow's Goldeneye
Hooded Merganser
Red-breasted Merganser
Harlans Hawk
Broad-winged Hawk
Hawk Owl
Black-bellied Plover
Lesser Yellowlegs
Least Sandpiper
Western Sandpiper
Long-billed Dowitcher
Black-necked Stilt
Northern Phalarope
Herring Gull
Franklin's Gull
Bonaparte's Gull
Forester's Tern
Black Tern
Common Tern
Yellow-billed Cuckoo
White-throated Swift
Varied Thrush
Water Pipit
Bohemian Waxwing
Northern Shrike
Townsend's Warbler
Bison

APPENDIX G. EFFECT OF POWER PLANT DEVELOPMENT ON POPULATION

The following six tables give an example of the population increase that may be created by the construction and operation of two 50 megawatt geothermal power plants. The tables show population increases related to direct employment requirements at the plants over thirteen years, which includes the four development phases of exploration, test drilling, construction, and operation. Each table represents two power plants at a different location within the IPGA. The zones in the table headings designate the location of the plants and correspond to the zones shown in the socio-economic analysis zones map (map 20). Each table assumes that both plants would be constructed in one zone simultaneously. A computer program was prepared to generate the six tables.

The column headings of all tables are the same. The following is an explanation of each column heading from left to right:

YEAR—This is the years of development.

DIRECT EMPLOYMENT—The actual employment required in each year for the two power plants.

INMIGRANT FACTOR—The percentage, expressed as a decimal, of direct employment which will come from outside the IPGA.

INMIGRANT NUMBER—The number of employees which will come from outside the IPGA.

AVERAGE FAMILY SIZE MULTIPLIER—Measures the increase in population created by the families of the direct employees. Note that this factor increases during operation (years 5-13). More operation phase employees are expected to have their families in the area due to longer term employment.

INDIRECT MULTIPLIER—Measures the increase in population that would be created by the demand for supporting services required by plant employees. This multiplier effect is due to the needs of these workers and families for housing, food, and services. These needs stimulate further economic growth and population increase.

TOTAL POPULATION—The total population increase expected to be created by the two plants.

The right eight columns represent how the TOTAL POPULATION is expected to be distributed among the communities within and adjacent to the IPGA.

ST. ANTHONY FACTOR—The percentage of TOTAL POPULATION, expressed as a decimal, expected to move into the community of St. Anthony, Idaho.

ST. ANTHONY TOTAL—The number of people expected to move into St. Anthony, Idaho.

ASHTON FACTOR—The percentage of TOTAL POPULATION, expressed as a decimal, expected to move into the community of Ashton, Idaho.

ASHTON TOTAL—The number of people expected to move into Ashton, Idaho.

WEST YELLOWSTONE FACTOR—The percentage of TOTAL POPULATION, expressed as a decimal, expected to move into the community of West Yellowstone, Montana.

WEST YELLOWSTONE TOTAL—The number of people expected to move into West Yellowstone, Montana.

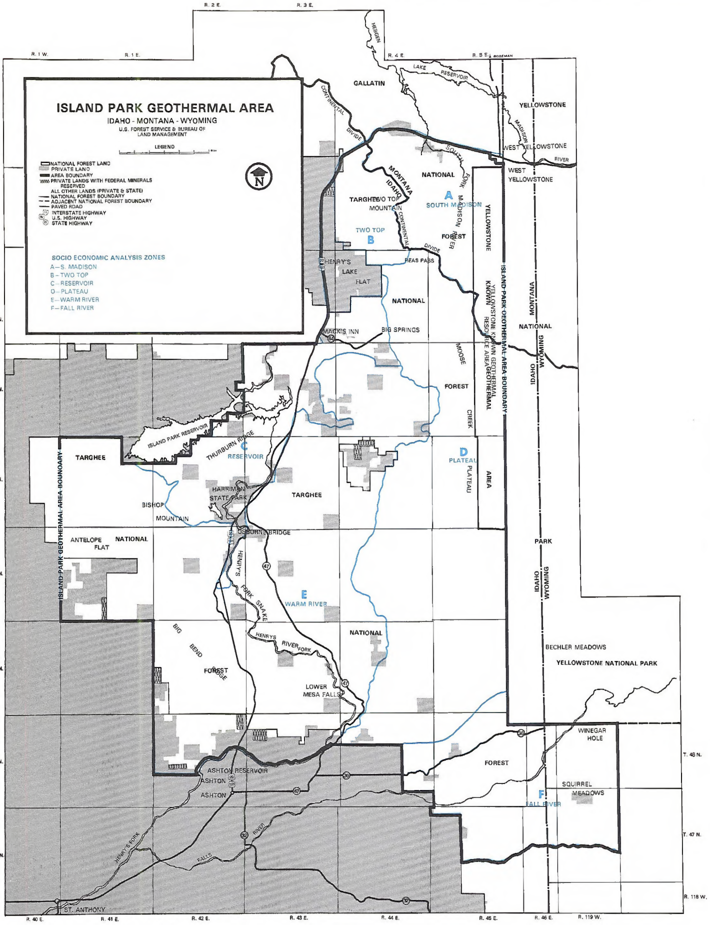
ISLAND PARK FACTOR—The percentage of TOTAL POPULATION, expressed as a decimal, expected to move into the community of Island Park, Idaho.

ISLAND PARK TOTAL—The number of people expected to move into Island Park, Idaho.

As an example, refer to the second row of the Zone A table. In year 2, direct employment is expected to be 48 people, 80 percent of whom are expected to come from outside the IPGA. Family size and indirect services are each expected to increase population about 50 percent over direct employment for a total population increase of 86. (38 x 1.5 x 1.5 = 86). This population increase will be distributed as follows:

0 to St. Anthony, Idaho
20 percent (17 people) to Ashton, Idaho
60 percent (52 people) to West Yellowstone, Montana
20 percent (17 people) to Island Park, Idaho

MAP 20. SOCIO-ECONOMIC ANALYSIS ZONE



ISLAND PARK GEOTHERMAL STUDY
EFFECT OF POWER PLANT DEVELOPMENT ON POPULATION FOR DEVELOPMENT OF 2 50 MEGAWATT POWER PLANTS IN SIMULTANEOUS DEVELOPMENT

ZONE A

Year	Direct Employ-Ment	Inmigrant Factor	Inmigrant Number	Average Family Size Multiplier	Indirect Multiplier	Total Population	St. Anthony Factor	St. Anthony Total	Population Distribution Ashton Factor	Ashton Total	W. Yellowstone Factor	W. Yellowstone Total	Island Park Factor	Island Park Total
1.	14.	.90	13.	1.5	1.5	28.	.00	0.	.20	6.	.60	17.	.20	6.
2.	48.	.80	38.	1.5	1.5	86.	.00	0.	.20	17.	.60	52.	.20	17.
3.	248.	.80	198.	1.5	1.5	446.	.00	0.	.20	89.	.60	268.	.20	89.
4.	224.	.80	179.	1.5	1.5	403.	.00	0.	.20	81.	.60	242.	.20	81.
5.	50.	.95	47.	3.0	1.5	214.	.00	0.	.20	43.	.60	128.	.20	43.
6.	50.	.95	47.	3.0	1.5	214.	.00	0.	.20	43.	.60	128.	.20	43.
7.	50.	.95	47.	3.0	1.5	214.	.00	0.	.20	43.	.60	128.	.20	43.
8.	50.	.95	47.	3.0	1.5	214.	.00	0.	.20	43.	.60	128.	.20	43.
9.	50.	.95	47.	3.0	1.5	214.	.00	0.	.20	43.	.60	128.	.20	43.
10.	50.	.95	47.	3.0	1.5	214.	.00	0.	.20	43.	.60	128.	.20	43.
11.	50.	.95	47.	3.0	1.5	214.	.00	0.	.20	43.	.60	128.	.20	43.
12.	50.	.95	47.	3.0	1.5	214.	.00	0.	.20	43.	.60	128.	.20	43.
13.	50.	.95	47.	3.0	1.5	214.	.00	0.	.20	43.	.60	128.	.20	43.

ZONE B

Year	Direct Employ-Ment	Inmigrant Factor	Inmigrant Number	Average Family Size Multiplier	Indirect Multiplier	Total Population	St. Anthony Factor	St. Anthony Total	Population Distribution Ashton Factor	Ashton Total	W. Yellowstone Factor	W. Yellowstone Total	Island Park Factor	Island Park Total
1.	14.	.90	13.	1.5	1.5	28.	.20	6.	.30	9.	.25	7.	.25	7.
2.	48.	.70	34.	1.5	1.5	76.	.20	15.	.30	23.	.25	19.	.25	19.
3.	248.	.70	174.	1.5	1.5	391.	.20	78.	.30	117.	.25	98.	.25	98.
4.	224.	.70	157.	1.5	1.5	353.	.20	71.	.30	106.	.25	88.	.25	88.
5.	50.	.95	47.	3.0	1.5	214.	.20	43.	.30	64.	.25	53.	.25	53.
6.	50.	.95	47.	3.0	1.5	214.	.20	43.	.30	64.	.25	53.	.25	53.
7.	50.	.95	47.	3.0	1.5	214.	.20	43.	.30	64.	.25	53.	.25	53.
8.	50.	.95	47.	3.0	1.5	214.	.20	43.	.30	64.	.25	53.	.25	53.
9.	50.	.95	47.	3.0	1.5	214.	.20	43.	.30	64.	.25	53.	.25	53.
10.	50.	.95	47.	3.0	1.5	214.	.20	43.	.30	64.	.25	53.	.25	53.
11.	50.	.95	47.	3.0	1.5	214.	.20	43.	.30	64.	.25	53.	.25	53.
12.	50.	.95	47.	3.0	1.5	214.	.20	43.	.30	64.	.25	53.	.25	53.
13.	50.	.95	47.	3.0	1.5	214.	.20	43.	.30	64.	.25	53.	.25	53.

ZONE C

Year	Direct Employ-Ment	Inmigrant Factor	Inmigrant Number	Average Family Size Multiplier	Indirect Multiplier	Total Population	St. Anthony Factor	St. Anthony Total	Population Distribution Ashton Factor	Ashton Total	W. Yellowstone Factor	W. Yellowstone Total	Island Park Factor	Island Park Total
1.	14.	.90	13.	1.5	1.5	28.	.30	9.	.40	11.	.10	3.	.20	6.
2.	48.	.70	34.	1.5	1.5	76.	.30	23.	.40	30.	.10	8.	.20	15.
3.	248.	.70	174.	1.5	1.5	391.	.30	117.	.40	156.	.10	39.	.20	78.
4.	224.	.70	157.	1.5	1.5	353.	.30	106.	.40	141.	.10	35.	.20	71.
5.	50.	.95	47.	3.0	1.5	214.	.30	64.	.40	85.	.10	21.	.20	43.
6.	50.	.95	47.	3.0	1.5	214.	.30	64.	.40	85.	.10	21.	.20	43.
7.	50.	.95	47.	3.0	1.5	214.	.30	64.	.40	85.	.10	21.	.20	43.
8.	50.	.95	47.	3.0	1.5	214.	.30	64.	.40	85.	.10	21.	.20	43.
9.	50.	.95	47.	3.0	1.5	214.	.30	64.	.40	85.	.10	21.	.20	43.
10.	50.	.95	47.	3.0	1.5	214.	.30	64.	.40	85.	.10	21.	.20	43.
11.	50.	.95	47.	3.0	1.5	214.	.30	64.	.40	85.	.10	21.	.20	43.
12.	50.	.95	47.	3.0	1.5	214.	.30	64.	.40	85.	.10	21.	.20	43.
13.	50.	.95	47.	3.0	1.5	214.	.30	64.	.40	85.	.10	21.	.20	43.

ZONE D

Year	Direct Employ-Ment	Immigrant Factor	Immigrant Number	Average Family Size Multiplier	Indirect Multiplier	Total Population	St. Anthony Factor	St. Anthony Total	Population Distribution Ashton Factor	Ashton Total	W. Yellowstone Factor	W. Yellowstone Total	Island Park Factor	Island Park Total
1.	14.	.90	13.	1.5	1.5	28.	.35	10.	.35	10.	.15	4.	.15	4.
2.	48.	.70	34.	1.5	1.5	76.	.35	26.	.35	26.	.15	11.	.15	11.
3.	248.	.70	174.	1.5	1.5	391.	.35	137.	.35	137.	.15	59.	.15	59.
4.	224.	.70	157.	1.5	1.5	353.	.35	123.	.35	123.	.15	53.	.15	53.
5.	50.	.95	47.	3.0	1.5	214.	.35	75.	.35	75.	.15	32.	.15	32.
6.	50.	.95	47.	3.0	1.5	214.	.35	75.	.35	75.	.15	32.	.15	32.
7.	50.	.95	47.	3.0	1.5	214.	.35	75.	.35	75.	.15	32.	.15	32.
8.	50.	.95	47.	3.0	1.5	214.	.35	75.	.35	75.	.15	32.	.15	32.
9.	50.	.95	47.	3.0	1.5	214.	.35	75.	.35	75.	.15	32.	.15	32.
10.	50.	.95	47.	3.0	1.5	214.	.35	75.	.35	75.	.15	32.	.15	32.
11.	50.	.95	47.	3.0	1.5	214.	.35	75.	.35	75.	.15	32.	.15	32.
12.	50.	.95	47.	3.0	1.5	214.	.35	75.	.35	75.	.15	32.	.15	32.
13.	50.	.95	47.	3.0	1.5	214.	.35	75.	.35	75.	.15	32.	.15	32.

ZONE E

Year	Direct Employ-Ment	Immigrant Factor	Immigrant Number	Average Family Size Multiplier	Indirect Multiplier	Total Population	St. Anthony Factor	St. Anthony Total	Population Distribution Ashton Factor	Ashton Total	W. Yellowstone Factor	W. Yellowstone Total	Island Park Factor	Island Park Total
1.	14.	.90	13.	1.5	1.5	28.	.30	9.	.55	16.	.05	1.	.10	3.
2.	48.	.60	29.	1.5	1.5	65.	.30	19.	.55	36.	.05	3.	.10	6.
3.	248.	.60	149.	1.5	1.5	335.	.30	100.	.55	184.	.05	17.	.10	33.
4.	224.	.60	134.	1.5	1.5	302.	.30	91.	.55	166.	.05	15.	.10	30.
5.	50.	.95	47.	3.0	1.5	214.	.30	64.	.55	118.	.05	11.	.10	21.
6.	50.	.95	47.	3.0	1.5	214.	.30	64.	.55	118.	.05	11.	.10	21.
7.	50.	.95	47.	3.0	1.5	214.	.30	64.	.55	118.	.05	11.	.10	21.
8.	50.	.95	47.	3.0	1.5	214.	.30	64.	.55	118.	.05	11.	.10	21.
9.	50.	.95	47.	3.0	1.5	214.	.30	64.	.55	118.	.05	11.	.10	21.
10.	50.	.95	47.	3.0	1.5	214.	.30	64.	.55	118.	.05	11.	.10	21.
11.	50.	.95	47.	3.0	1.5	214.	.30	64.	.55	118.	.05	11.	.10	21.
12.	50.	.95	47.	3.0	1.5	214.	.30	64.	.55	118.	.05	11.	.10	21.
13.	50.	.95	47.	3.0	1.5	214.	.30	64.	.55	118.	.05	11.	.10	21.

ZONE F

Year	Direct Employ-Ment	Immigrant Factor	Immigrant Number	Average Family Size Multiplier	Indirect Multiplier	Total Population	St. Anthony Factor	St. Anthony Total	Population Distribution Ashton Factor	Ashton Total	W. Yellowstone Factor	W. Yellowstone Total	Island Park Factor	Island Park Total
1.	14.	.90	13.	1.5	1.5	28.	.30	9.	.60	17.	.00	0.	.10	3.
2.	48.	.65	31.	1.5	1.5	70.	.30	21.	.60	42.	.00	0.	.10	7.
3.	248.	.65	161.	1.5	1.5	363.	.30	109.	.60	218.	.00	0.	.10	36.
4.	224.	.65	146.	1.5	1.5	328.	.30	98.	.60	197.	.00	0.	.10	33.
5.	50.	.95	47.	3.0	1.5	214.	.30	64.	.60	128.	.00	0.	.10	21.
6.	50.	.95	47.	3.0	1.5	214.	.30	64.	.60	128.	.00	0.	.10	21.
7.	50.	.95	47.	3.0	1.5	214.	.30	64.	.60	128.	.00	0.	.10	21.
8.	50.	.95	47.	3.0	1.5	214.	.30	64.	.60	128.	.00	0.	.10	21.
9.	50.	.95	47.	3.0	1.5	214.	.30	64.	.60	128.	.00	0.	.10	21.
10.	50.	.95	47.	3.0	1.5	214.	.30	64.	.60	128.	.00	0.	.10	21.
11.	50.	.95	47.	3.0	1.5	214.	.30	64.	.60	128.	.00	0.	.10	21.
12.	50.	.95	47.	3.0	1.5	214.	.30	64.	.60	128.	.00	0.	.10	21.
13.	50.	.95	47.	3.0	1.5	214.	.30	64.	.60	128.	.00	0.	.10	21.

APPENDIX H. EMPLOYMENT CATEGORIES AND SPENDING

The following four tables estimate the spending that would be created by personnel employed in two fifty megawatt geothermal power plants. Each table represents a phase of geothermal development from exploration to operation of the power plants. The last table reflects spending during the operation phase, which is representative of the long-term employment and spending per year created by operation of the two plants.

The column headings are the same for each table. At the left side of each table is a column labeled "Category". These are the categories of personnel required for the phase. The middle column lists the number of personnel required for each category of employment. The spending of all employees per year in the category is listed in the right column. Spending is estimated at 1977 wage levels.

EMPLOYMENT CATEGORIES AND SPENDING
FOR TWO FIFTY MEGAWATT GEOTHERMAL POWER PLANTS

DURING THE EXPLORATION PHASE

Category	Number of People Employed	Spending of Employees Per Year
Various Specialists	8	$22,800
Drillers	6	26,450
Total for Phase	14	$49,250

TEST DRILLING

Category	Number of People Employed	Spending of Employees Per Year
Geologist	6	$ 34,000
Landman	4	16,600
Drillers	12	105,800
Truck Drivers	4	39,400
Administrative	4	31,600
Geophysicists	4	25,400
Drill Rig Foremen	4	46,600
Laborers	8	52,600
Geochemists	2	25,400
Total for Phase	48	$377,400

CONSTRUCTION AND DEVELOPMENT

Category	Number of People Employed	Spending of Employees Per Year
Engineers	10	$ 18,600
Inspectors	6	17,800
Foremen	10	116,600
Pipefitters	18	210,000
Millwrights	8	81,600
Instrument Technicians	6	53,000
Truck Drivers	8	79,000
Timekeepers	2	13,200
Common Laborers	18	118,200
Surveyors	2	17,000
Superintendents	2	23,400
Electricians	10	116,600
Welders	10	111,800
Iron Workers	8	85,600
Concrete Workers	12	118,400
Carpenters	8	77,800
Insulation Installers	8	66,400
Sheetmetel Workers	8	70,600
Plumbers	8	93,332
Tilesetters	4	35,200
Painters	8	85,600
Machinists	4	40,800
Riggers	6	56,000
Crane Operators	4	40,800
Warehousemen	4	50,600
Administration	8	63,000
Total for Phase	200	$1,860,932

OPERATION

Category	Number of People Employed	Spending of Employees Per Year
Plant Supervisors	2	$ 25,400
Plant Operators	22	259,600
Instrument Technicians	2	17,600
Welders	2	22,400
Laborers	4	26,200
Shift Foremen	8	93,400
Mechanical Engineers	2	25,400
Machinists	2	20,400
Pipefitters	2	23,400
Electricians	2	23,400
Administrative	2	15,800
Total for Phase	50	$553,000

APPENDIX I. POTENTIAL SOCIAL IMPACTS OF GEOTHERMAL DEVELOPMENT

Three principle questions are considered in regard to geothermal development:

1. Do local residents' attitudes change after development is begun?
2. Do local residents enjoy greater employment because of the development, and do they have the skills needed for the jobs available?
3. Will the local governments have the financial ability to provide extra services needed because of possible geothermal development?

In determining if local residents' attitudes change after development is begun, it is worthwhile to analyze the example of Colstrip, Montana.

In 1970 Colstrip, Montana was a community of about 200 persons. In 1972 construction of units 1 and 2 of Colstrip Electrical Generating Plant began. By 1975 the population of the town was estimated to be about 3,000 people. Colstrip had severe impact in terms of population growth.

Colstrip is an isolated community. It is 35 miles from Interstate 94 and 38 miles from Forsyth, a town of 3,000 population. Billings or Miles City, Montana, the area's trade and service centers, are over two hours driving time. Services in Colstrip, especially commercial and entertainment facilities, are severely limited. The town has had much to do just to keep basic services at an acceptable level.

In 1975 a study was completed on Colstrip by the Old West Regional Commission. The purpose of this study was to learn something of the effects which large scale construction projects have on small communities. A household survey from 148 households in Colstrip was conducted by the Old West Regional Commission's consultant, Mountain West Research, Inc. This represented a 14.8% sample of total households.

The longtime residents of Colstrip were asked a few questions about how they felt about the effects which the construction of Colstrip units 1 and 2 were having on the community and its residents. When asked whether the effects of the construction were the same, better or worse than they expected most (66.7%) answered the same; 13.9% felt the effects were better than expected and 19.4% felt they were worse than expected. The reason given most frequently for thinking the effects were better than expected was desirable people arriving; given by 40% of the respondents. The reasons given most frequently for thinking effects were worse than expected was inadequacy of community facilities, given by 28.6% of the respondents.

When asked whether they were glad or unhappy that the project was there at all, a great majority of respondents (86.1%) said that they were glad. The reason most frequently given for being glad the project was under way in Colstrip was, "job opportunities" (58% of the glad respondents). The reason most frequently given for being unhappy about the project was increased population (60% of the unhappy respondents). There was no apparent differences in opinion according to respondent households, education, income, occupation or length of residence.

With regard to geothermal development on the IPGA, the location, magnitude, and timing of the geothermal development are the major attributes that determine impact. The location of a geothermal development will be important to the distribution of social impacts among neighboring communities. The most important cause of social impacts will be the magnitude of the geothermal development.

As an example of the employment opportunities that may be created by geothermal development in the IPGA, refer to appendix H. These tables show the employment requirements for two 50 megawatt geothermal power plants. A brief review of these tables show that many positions available at the geothermal development can use local people with a brief amount of training.

The communities that receive the greatest fiscal impacts and most rapid percentage increases in population also experience the greatest difficulty finding the money to keep the quality of their public services in step with the population increase. This simple analysis does not apply to the IPGA because two of the potential impacted towns are not typical communities. Island Park and West Yellowstone are seasonal resort communities. The town of Island Park has no budget. West Yellowstone's overnight population grows from its off season low of about 800 to more than 6,000 in the peak of the summer, with over 12,000 people in town during a peak July day.

The present budget for each of the four towns is listed in the following table. The higher per capita expenditure rate in West Yellowstone reflects the seasonal tourist economy.

TOWN BUDGETS

	1977-78 Budget	Estimated Per Capita Budget
St. Anthony, Idaho	$476,401	$152
Ashton, Idaho	202,414	$162
Island Park, Idaho	0	0
West Yellowstone, Montana	186,335	218

The public officials interviewed generally felt optimistic about their ability to cope with growth. St. Anthony received as many workers and their families during the construction of the Teton Dam in the early 70's.

Because population has been increasing slowly in the recent past, each of the towns is in a generally sound fiscal situation. The tax burden in St. Anthony is carried primarily by the residents since there is no major industry in the town. In contrast, West Yellowstone's major burden is carried by the tourist related businesses.

The cost of geothermal development to the towns will be borne in part by the return of income from the leases. It is difficult to estimate the quantity or predict that it will be a significant amount. Most of the lease applications are noncompetitive, if granted they will only bring in $1.00 per acre per year until a geothermal resource is found and developed. The distribution of this money once it returns to the state varies from state to state. In Idaho at least 5% of the original income is guaranteed to return to the county of origin. The actual amount to the affected communities will vary and depends to some extent on discretionary decisions at the state level. For noncompetitive leases the income to the communities in the IPGA will probably not be substantial until after the construction peak has been reached and passed.

The fiscal impacts on the communities can be summarized as follows:

Geothermal development may cause fiscal strain for St. Anthony and Ashton during the construction phase, but the long-term impact of operations of the development will be more manageable due to lower employment levels. Island Park is a more serious problem. Present controversy over a proposed sewage system and the lack of a town budget or service delivery capability are problems that will be accentuated by geothermal development.

West Yellowstone is best equipped by a tradition of fluctuating population to cope with short term construction period demands of geothermal development.

The greatest assistance other than monetary that can be given the communities to assist them with their fiscal policy is early and continuous information on what will happen, what is happening and what has happened with regard to each lease and geothermal development.

References:

EDAW Inc., Island Park Geothermal Energy Development-Social and Economic Assessment, Dec., 1977.

Old West Regional Commission, Construction Worker Profile, Colstrip and Forsyth, Montana, Dec., 1975.

APPENDIX J. SPACE HEATING CONSIDERATIONS FOR WEST YELLOWSTONE, MONTANA

West Yellowstone appears to be the most promising community in or near the IPGA for geothermal space heating due to its location and relatively high population density. This appendix discusses some of the factors which are important when considering geothermal space heating. These are:

- Cost of wells
- Cost of pipes, pumps, meters, valves, storage tanks
- Operation and maintenance expense
- Temperature of the geothermal fluid
- Flow conditions of the geothermal fluid
- Distance of geothermal fluid transmission
- Total population of the area to be heated
- Population density
- Heating system installation costs
- Cost of heat from alternative energy sources
- Institutional deterrents

The largest costs for geothermal energy production are the initial costs of the producing wells. Well costs are mainly a function of depth. Geothermal wells currently (1977) cost about $300,000 per kilometer (about $100 per foot). The depth to 90°C-150°C (194°F-302°F) geothermal resources suitable for heating is estimated by the U.S. Geological Survey to be 1 to 1½ kilometers (3280-4920 feet) in most instances. Operating and maintenance expenses including well redrilling and pumping costs will usually be small in proportion to the initial cost of the wells.

The distance of geothermal fluid transmission will be a limiting factor for non-electric applications of geothermal energy. Transmission distances for existing geothermal applications are short, rarely exceeding 15 kilometers (9.32 miles). Although oil and gas can be economically piped over thousands of miles, the economic limitations for geothermal fluids will probably be less than 100 miles because of the low energy content of the fluid. Fuel oil contains about 100 times more energy per unit volume than hot water.

The total population of the area to be heated influences heating costs in two ways. First, with increasing population, economies of scale are realized in the piping for the distribution network. For example, pipe weight and costs increase near linearly with diameter while flow capacity increases with the square of the diameter. A minimum district size of 1,000 dwelling units or equivalent, will probably be required for economic feasibility. Second, increasing population reduces cost per dwelling unit heated associated with the investment in wells up to the point at which the maximum well flow is fully utilized.

Population density is one of the most important factors affecting heating costs. Increased population density reduces heating costs through reducing the average length of pipe run. With very high population densities such as large multi-story apartment buildings, economies of scale are realized in the distribution system through the use of large diameter pipe.

The cost of installing geothermal heating systems in established residential and commercial areas will generally be higher than in new developments. Trenching costs will be higher because existing streets and sidewalks must be dug up and replaced. Indirect routing of geothermal heating lines around existing sewer and water lines will also increase installation costs. Based on limited data from Iceland, construction costs for geothermal heating systems in established areas will be 10 to 30% higher than costs in new areas.

The retrofitting costs for replacing existing heating systems in residential and commercial buildings with hot water heating systems will be a deterrent to geothermal hot water heating. Retrofitting is estimated to cost $500 to $2,000 per dwelling unit. The lower part of the cost range would apply to the conversion of an existing forced air hot water system.

At the present time heat from geothermal sources would probably not be competitive with heat from electricity or coal in the West Yellowstone area. As costs of fuel from these energy sources continue to rise, geothermal space heating may become more competitive.

Institutional deterrents to widespread non-electric applications of geothermal energy will probably be significant. These include acquisition of rights-of-way for pipeline, the need to organize concentrated markets and price competition from the conventional fuels.

The greatest problem with geothermal heating in West Yellowstone is the small number of potential heating units. The large initial investment would require at least 1,000 homes or commercial buildings or a combination of the two for geothermal heat to be competitive with present fuels and to be economically feasible.

References:

Geothermal Energy Potential For District & Process Heating in the U.S.—An Economic Analysis, Bloomster et al, Batelle Laboratories, August, 1977.

Island Park Geothermal Energy Development-Social and Economic Assessment, EDAW Inc., December 25, 1977.

Form 3200–21
(May 1974)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

GEOTHERMAL RESOURCES LEASE

☐ Competitive ☐ Noncompetitive

Serial Number

USGS – KGRA Determination:

In consideration of the terms and conditions contained herein, and the grant made hereby, this lease is entered into by the UNITED STATES OF AMERICA (hereinafter called the "Lessor"), acting through the Bureau of Land Management (hereinafter called the "Bureau") of the Department of the Interior (hereinafter called the "Department"), and

(hereinafter called the "Lessee").

This lease is made pursuant to the Geothermal Steam Act of 1970 (84 Stat. 1566; 30 U.S.C. 1001–1025) (hereinafter called "the Act") to be effective on (hereinafter called the "effective date"). It is subject to all the provisions of the Act and to all the terms, conditions, and requirements of (a) all regulations promulgated by the Secretary of the Interior (hereinafter called "the Secretary") in existence upon the effective date, specifically including, but not limited to, 43 CFR Parts 3000 and 3200 and 30 CFR Parts 270 and 271, (b) all geothermal resources operational orders (hereinafter called "GRO orders") issued pursuant thereto, all of which are incorporated herein and by reference made a part hereof, and (c) any regulations hereafter issued by the Secretary (except those inconsistent with any specific provisions of this lease other than regulations incorporated herein by reference) all of which shall be, upon their effective date, incorporated herein and, by reference, made a part hereof.

Sec. 1. GRANT – The Lessor hereby grants and leases to the Lessee the exclusive right and privilege to drill for, extract, produce, remove, utilize, sell, and dispose of geothermal steam and associated geothermal resources, (hereinafter called "geothermal resources"), in or under the following described lands situated within the County of

State of ;

National Resource Lands	Acquired Lands
T. ; R. ; Meridian	T. ; R. ; Meridian
Total Area	Total Area

Containing acres (hereinafter called the "leased area" or "leased lands"), together with:

(a) The nonexclusive right to conduct within the leased area geological and geophysical exploration in accordance with applicable regulations, and

(b) The right to construct or erect and to use, operate, and maintain within the leased area, together with ingress and egress thereupon all wells, pumps, pipes, pipelines, buildings, plants, sumps, brine pits, reservoirs, tanks, waterworks, pumping stations, roads, electric power generating plants, transmission lines, industrial facilities, electric, telegraph or telephone lines, and such other works and structures and to use so much of the surface of the land as may be necessary or reasonably convenient for the production, utilization, and processing of geothermal resources or to the full enjoyment of the rights granted by this lease, subject to compliance with applicable laws and regulations; *Provided that,* although the use of the leased area for an electric power generating plant or transmission facilities or a commercial or industrial facility is authorized hereunder, the location of such facilities and the terms of occupancy therefor shall be under separate instruments issued under any applicable laws and regulations; and

(c) The nonexclusive right to drill potable water wells in accordance with state water laws within the leased area and to use the water produced therefrom for operations on the leased lands free of cost, provided that such drilling and development are conducted in accordance with procedures approved by the Supervisor of the Geological Survey (hereinafter called "Supervisor"); and

(d) The right to convert this lease to a mineral lease under the Mineral Leasing Act of February 25, 1920, as amended, and supplemented (30 U.S.C. 181–287) or under the Mineral Leasing Act for Acquired Lands (30 U.S.C. 351–359), whichever is appropriate, if the leasehold is primarily valuable for the production of one or more valuable by-products which are leasable under those statutes, and the lease is incapable of commercial production or utilization of geothermal steam: *Provided that,* an application is made therefor prior to the expiration of the lease extension by reason of by-product production as hereinafter provided, and subject to all the terms and conditions of said appropriate Acts. The Lessee is also granted the right to locate mineral deposits under the mining laws (30 U.S.C. 21–54), which would constitute by-products if commercial production or utilization of geothermal steam continued, but such a location to be valid must be completed within ninety (90) days after the termination of this lease. Any conversion of this lease to a mineral lease or a mining claim is contingent on the availability of such lands for this purpose at the time of the conversion. If the lands are withdrawn or acquired in aid of a function of any Federal Department or agency, the mineral lease or mining claim shall be subject to such additional terms and conditions as may be prescribed by such Department or agency for the purpose of making operations thereon consistent with the purposes for which these lands are administered; and

(e) The right, without the payment of royalties hereunder, to reinject into the leased lands geothermal resources and condensates to the extent that such resources and condensates are not utilized, but their reinjection is necessary for operations under this lease in the recovering or processing of geothermal resources. If the Lessee, pursuant to any approved plan, disposes of the unusable brine and produced waste products into underlying formations, he may do so without the payment of royalties.

Sec. 2. TERM

(a) This lease shall be for a primary term of ten (10) years from the effective date and so long thereafter as geothermal steam is produced or utilized in commercial quantities but shall in no event continue for more than forty (40) years after the end of the primary term. However, if at the end of that forty-year period geothermal steam is being produced or utilized in commercial quantities, and the leased lands are not needed for other purposes, the Lessee shall have a preferential right to a renewal of this lease for a second forty-year term in accordance with such terms and conditions as the Lessor deems appropriate.

(b) If actual drilling operations are commenced on the leased lands or under an approved plan or agreement on behalf of the leased lands prior to the end of the primary term, and are being diligently prosecuted at the end of the primary term, this lease shall be extended for five (5) years and so long thereafter, but not more than thirty-five (35) years, as geothermal steam is produced or utilized in commercial quantities. If at the end of such extended term geothermal steam is being produced or utilized in commercial quantities, the Lessee shall have a preferential right to a renewal for a second term as in (a) above.

(c) If the Lessor determines at any time after the primary term that this lease is incapable of commercial production and utilization of geothermal steam, but one or more valuable by-products are or can be produced in commercial quantities, this lease shall be extended for so long as such by-products are produced in commercial quantities but not for more than five (5) years from the date of such determination.

Sec. 3. RENTALS AND ROYALTIES

(a) *Annual Rental* – For each lease year prior to the commencement of production of geothermal resources in commercial quantities on the leased lands, the Lessee shall pay the Lessor on or before the anniversary date of the lease a rental of $ for each acre or fraction thereof.

(b) *Escalating Rental* – Beginning with the sixth lease year and for each year thereafter until the lease year beginning on or after the commencement of production of geothermal resources in commercial quantities, the Lessee shall pay on or before the anniversary date of the lease an escalated rental in an amount per acre or fraction thereof equal to the rental per acre for the preceding year and an additional sum of one (1) dollar per acre or fraction thereof. If the lease is extended beyond ten (10) years for reasons other than the commencement of production of geothermal resources in commercial quantities, the rental for the eleventh year and for each lease year thereafter until the lease year beginning on or after the commencement of such production will be the amount of rental for the tenth lease year. If any expenditures are made in any lease year for diligent exploration on the leased lands in excess of the minimum required expenditures for that year, the excess may be credited against any rentals in excess of $ per acre or fraction thereof due the Lessor for that or any future year.

(c) *Royalty* – On or before the last day of the calendar month after the month of commencement of production in commercial quantities of geothermal resources and thereafter on a monthly basis, the Lessee shall pay to the Lessor:

(1) A royalty of percent on the amount or value of steam, or any other form of heat or other associated energy produced, processed, removed, sold, or utilized from this lease or reasonably susceptible to sale or utilization by the Lessee.

(2) A royalty of percent of the value of any by-product derived from production under this lease, produced, processed, removed, sold, or utilized from this lease or reasonably susceptible of sale or utilization by the Lessee, except that as to any by-product which is a mineral named in Sec. 1 of the Mineral Leasing Act of February 25, 1920, as amended, (30 U.S.C. 181), the rate of royalty for such mineral shall be the same as that provided in that statute and the maximum rate of royalty for such mineral shall not exceed the maximum royalty applicable under that statute.

(3) A royalty of percent of the value of commercially demineralized water which has been produced from the leased lands, and has been sold or utilized by the Lessee or is reasonably susceptible of sale or utiltzation by the Lessee. In no event shall the Lessee pay to the Lessor, for the lease year beginning on or after the commencement of production in commercial quantities on the leased lands or any subsequent lease year, a royalty of less than two (2) dollars per acre or fraction thereof. If royalty paid on production during the lease year has not satisfied this requirement, the Lessee shall pay the difference on or before the expiration date of the lease year for which it is paid.

(d) *Waiver and Suspension of Rental and Royalties* – Rentals or royalties may be waived, suspended, or reduced pursuant to the applicable regulations on the entire leasehold or any portion thereof in the interest of conservation or for the purpose of encouraging the greatest ultimate recovery of geothermal resources if the Lessor determines that it is necessary to do so to promote such development, or because the lease cannot be successfully operated under the terms fixed herein.

(e) *Undivided Fractional Interests* – Where the interest of the Lessor in the geothermal resources underlying any tract or tracts described in Sec. 1 is an undivided fractional interest, the rentals and royalties payable on account of each such tract shall be in the same proportion to the rentals and royalties provided in this lease as the individual fractional interest of the Lessor in the geothermal resources underlying such tract is to the full fee interest.

(f) *Readjustments* – Rentals and royalties hereunder may be readjusted in accordance with the Act and regulations to rates not in excess of the rates provided therein, and at not less than twenty (20) year intervals beginning thirty-five (35) years after the date geothermal steam is produced from the lease as determined by the Supervisor.

Sec. 4. PAYMENTS – It is expressly understood that the Secretary may establish the values and minimum values of geothermal resources to compute royalties in accordance with the applicable regulations. Unless otherwise directed by the Secretary, all payments to the Lessor will be made as required by the regulations. If there is no well on the leased lands capable of producing geothermal resources in commercial quantities, the failure to pay rental on or before the anniversary date shall cause the lease to terminate by operation of law except as provided by Sec. 3244.2 of the regulations. If the time for payment falls on a day on which the proper office to receive payment is closed, payment shall be deemed to be made on time if made on the next official working day.

Sec. 5. BONDS – The Lessee shall file with the Authorized Officer of the Bureau (hereinafter called the "Authorized Officer") shall maintain at all times the bonds required under the regulations to be furnished as a condition to the issuance of this lease or prior to entry on the leased lands in the amounts established by the Lessor and to furnish such additional bonds or security as may be required by the Lessor upon entry on the lands or after operations or production have begun.

Sec. 6. WELLS

(a) The Lessee shall drill and produce all wells necessary to protect the leased land from drainage by operations on lands not the property of the Lessor, or other lands of the Lessor leased at a lower royalty rate, or on lands as to which royalties and rentals are paid into different funds from those into which royalties under this lease are paid. However, in lieu of any part of such drilling and production, with the consent of the Supervisor, the Lessee may compensate the Lessor in full each month for the estimated loss of royalty through drainage in the amount determined by said Supervisor.

(b) At the Lessee's election, and with the approval of the Supervisor, the Lessee shall drill and produce other wells in conformity with any system of well spacing or production allotments affecting the field or area in which the leased lands are situated, which is authorized by applicable law.

(c) After due notice in writing, the Lessee shall diligently drill and produce such wells as the Supervisor shall require so that the leased lands may be properly and timely developed and for the production of geothermal steam and its by-products, including commercially demineralized water for beneficial uses in accordance with applicable state laws. However, the Supervisor may waive or modify the requirements of this subparagraph (c) in the interest of conservation of natural resources or for economic feasibility or other reasons satisfactory to him. If the products or by-products of geothermal production from wells drilled on this lease are susceptible of producing commercially demineralized water for beneficial uses, and a program therefor is not initiated with due diligence, the Lessor may at its option elect to take such products or by-products and the Lessee shall deliver all or any portion thereof to the Lessor at any point in the Lessee's geothermal gathering or disposal system without cost to the Lessee, if the Lessee's activities, under the lease, would not be impaired and such delivery would otherwise be consistent with field and operational requirements. The retention of this option by the Lessor shall in no way relieve the Lessee from the duty of producing commercially demineralized water where required to do so by the Lessor, except when the option is being exercised and then only with respect to wells where it is being exercised, or limit the Lessor's right to take any action under Sec. 25 to enforce that requirement.

Sec. 7. INSPECTION – The Lessee shall keep open at all reasonable times for the inspection of any duly apthorized representative of the Lessor the leased lands and all wells, improvements, machinery, and fixtures thereon and all production reports, maps, records, books, and accounts relative to operations under the lease, and well logs, surveys, or investigations of the leased lands.

Sec. 8. CONDUCT OF OPERATIONS – The Lessee shall conduct all operations under this lease in a workmanlike manner and in accordance with all applicable statutes, regulations, and GRO orders, and all other appropriate directives of the Lessor to prevent bodily injury, danger to life or health, or property damage, and to avoid the waste of resources, and shall comply with all requirements which are set forth in 43 CFR Group 3200, including, but not limited to, Subpart 3204, or which may be prescribed by the Lessor pursuant to the regulations, and with the special stipulations which are attached to the lease, all of which are specifically incorporated into this lease. A breach of any term of this lease, including the stipulations attached hereto, will be subject to all the provisions of this lease with respect to remedies in case of default. Where any stipulation is inconsistent with a regular provision of this lease, the stipulation shall govern.

Sec. 9. INDEMNIFICATION

(a) The Lessee shall be liable to the Lessor for any damage suffered by the Lessor in any way arising from or connected with the Lessee's activities and operations conducted pursuant to this lease, except where damage is caused by employees of the Lessor acting within the scope of their authority.

(b) The Lessee shall indemnify and hold harmless the Lessor from all claims arising from or connected with the Lessee's activities and operations under this lease.

(c) In any case where liability without fault is imposed on the Lessee pursuant to this section, and the damages involved were caused by the action of a third party, the rules of subrogation shall apply in accordance with the law of the jurisdiction where the damage occurred.

Sec. 10. CONTRACTS FOR SALE OR DISPOSAL OF PRODUCTS – The Lessee shall file with the Supervisor not later than thirty (30) days after the effective date thereof any contract, or evidence of other arrangement for the sale or disposal of geothermal resources.

Sec. 11. ASSIGNMENT OF LEASE OR INTEREST THEREIN – Within ninety (90) days from the date of execution thereof, the Lessee shall file for approval by the Authorized Officer any instruments of transfer made of this lease or of any interest therein, including assignments of record title and working or other interests.

Sec. 12. REPDRTS ANO DTHER INFDRMATIDN – At such times and in such form as the Lessor may prescribe, the Lessee shall comply with all reporting requirements of the geotbermal resources leasing, operating, and unit regulations and shall submit quarterly reports containing the data which it has collected through the monitoring of air, land, and water quality and all other data pertaining to the effect on the environment by operations under the lease. The Lessee shall also comply with such other reporting requirements as may be imposed by the Authorized Officer or the Supervisor. The Lessor may release to the general public any reports, maps, or other information submitted by the Lessee except geologic and geophysical interpretations, maps, or data subject to 30 CFR 270.79 or unless the Lessee shall designate that information as proprietary and the Supervisor or the Authorized Officer shall approve that designation.

Sec. 13. OILIGENT EXPLORATION – In the manner required by the regulations, the Lessee shall diligently explore the leased lands for geothermal resourees until there is production in commereial quantities applicable to this lease. After the fifth year of the primary term the Lessee shall make at least

APPENDIX K. LEASE FORM

the minimum expenditures required to qualify the operations on the leased lands as diligent exploration under the regulations.

Sec. 14. PROTECTION OF THE ENVIRONMENT (LAND, AIR AND WATER) AND IMPROVEMENTS – The Lessee shall take all mitigating actions required by the Lessor to prevent: (a) soil erosion or damage to crops or other vegetative cover on Federal or non-Federal lands in the vicinity; (b) the pollution of land, air, or water; (c) land subsidence, seismic activity, or noise emissions; (d) damage to aesthetic and recreational values; (e) damage to fish or wildlife or their habitats; (f) damage to or removal of improvements owned by the United States or other parties; or (g) damage to or destruction or loss of fossils, historic or prehistoric ruins, or artifacts. Prior to the termination of bond liability or at any other time when required and to the extent deemed necessary by the Lessor, the Lessee shall reclaim all surface disturbances as required, remove or cover all debris or solid waste, and, so far as possible, repair the offsite and onsite damage caused by his activity or activities incidental thereto, and return access roads or trails and the leased lands to an acceptable condition including the removal of structures, if required. The Supervisor or the Authorized Officer shall prescribe the steps to be taken by Lessee to protect the surface and the environment and for the restoration of the leased lands and other lands affected by operations on the leased lands and improvements thereon, whether or not the improvements are owned by the United States. Timber or mineral materials may be obtained only on terms and conditions imposed by the Authorized Officer.

Sec. 15. WASTE – The Lessee shall use all reasonable precautions to prevent waste of natural resources and energy, including geothermal resources, or of any minerals, and to prevent the communication of water or brine zones with any oil, gas, fresh water, or other gas or water bearing formations or zones which would threaten destruction or damage to such deposits. The Lessee shall monitor noise, air, and water quality conditions in accordance with any orders of the Supervisor.

Sec. 16. MEASUREMENTS – The Lessee shall gauge or otherwise measure all production, sales, or utilization of geothermal resources and shall record the same accurately in records as required by the Supervisor. Reports on production, sales, or utilization of geothermal resources shall be submitted in accordance with the terms of this lease and the regulations.

Sec. 17. RESERVATIONS TO LESSOR – All rights in the leased area not granted to the Lessee by this lease are hereby reserved to the Lessor. Without limiting the generality of the foregoing such reserved rights include:

(a) *Disposal* – The right to sell or otherwise dispose of the surface of the leased lands or any resource in the leased lands under existing laws, or laws hereafter enacted, subject to the rights of the Lessee under this lease;

(b) *Rights-of-way* – The right to authorize geological and geophysical explorations on the leased lands which do not interfere with or endanger actual operations under this lease, and the right to grant such easements or rights-of-way for joint or several use upon, through or in the leased area for steam lines and other public or private purposes which do not interfere with or endanger actual operations or facilities constructed under this lease;

(c) *Mineral Rights* – The ownership of and the right to extract oil, hydrocarbon gas, and helium from all geothermal steam and associated geothermal resources produced from the leased lands;

(d) *Casing* – The right to acquire the well and casing at the fair market value of the casing where the Lessee finds only potable water, and such water is not required in lease operations; and

(e) *Measurements* – The right to measure geothermal resources and to sample any production thereof.

Sec. 18. ANTIQUITIES AND OBJECTS OF HISTORIC VALUE – The Lessee shall immediately bring to the attention of the Authorized Officer any antiquities or other objects of historic or scientific interest, including but not limited to historic or prehistoric ruins, fossils, or artifacts discovered as a result of operations under this lease, and shall leave such discoveries intact. Failure to comply with any of the terms and conditions imposed by the Authorized Officer with regard to the preservation of antiquities may constitute a violation of the Antiquities Act (16 U.S.C. 431-433). Prior to operations, the Lessee shall furnish to the Authorized Officer a certified statement that either no archaeological values exist or that they may exist on the leased lands to the best of the of the Lessee's knowledge and belief and that they might be impaired by geothermal operations. If the Lessee furnishes a statement that archaeological values may exist where the land is to be disturbed or occupied, the Lessee will engage a qualified archaeologist, acceptable to the Authorized Officer, to survey and salvage, in advance of any operations, such archaeological values on the lands involved. The responsibility for the cost for the certificate, survey, and salvage will be borne by the Lessee, and such salvaged property shall remain the property of the Lessor or the surface owner.

Sec. 19. DIRECTIONAL DRILLING – A directional well drilled under the leased area from a surface location on nearby land not covered by the lease shall be deemed to have the same effect for all purposes of this lease as a well drilled from a surface location on the leased area. In such circumstances, drilling shall be considered to have been commenced on the nearby land for the purposes of this lease, and production of geothermal resources from the leased area through any directional well located on nearby land, or drilling or reworking of any such directional well shall be considered production or drilling or reworking operations (as the case may be) on the leased area for all purposes of this lease. Nothing contained in this section shall be construed as granting to the Lessee any right in any land outside the leased area.

Sec. 20. OVERRIDING ROYALTIES – The Lessee shall not create overriding royalties of less than one-quarter (1/4) of one percent of the value of output nor in excess of 50 percent of the rate of royalty due to the Lessor specified in Sec. 3 of this lease except as otherwise authorized by the regulations. The Lessee expressly agrees that the creation of any overriding royalty which does not provide for a prorated reduction of all overriding royalties so that the aggregate rate of royalties does not exceed the maximum rate permissible under this section, or the failure to suspend an overriding royalty during any period when the royalties due to the Lessor have been suspended pursuant to the terms of this lease, shall constitute a violation of the lease terms.

Sec. 21. READJUSTMENT OF TERMS AND CONDITIONS – The terms and conditions of this lease other than those related to rentals and royalties may be readjusted in accordance with the Act at not less than ten-year intervals beginning ten (10) years after the date geothermal steam is produced from the leased premises as determined by the Supervisor.

Sec. 22. COOPERATIVE OR UNIT PLAN – The Lessee agrees that it will on its own, or at the request of the Lessor where it is determined to be necessary for the conservation of the resource or to prevent the waste of the resource, subscribe to and operate under any reasonable cooperative or unit plan for the development and operation of the area, field, or pool, or part thereof embracing the lands subject to this lease as the Secretary may determine to be practicable and necessary or advisable in the interest of conservation. In the event the leased lands are included within a unit, the terms of this lease shall be deemed to be modified to conform to such unit agreement. Where any provision of a cooperative or unit plan of development which has been approved by the Secretary, and which by its terms affects the leased area or any part thereof, is inconsistent with a provision of this lease, the provisions of such cooperative or unit plan shall govern.

Sec. 23. RELINQUISHMENT OF LEASE – The Lessee may relinquish this entire lease or any officially designated subdivision of the leased area in accordance with the regulations by filing in the proper BLM office a written relinquishment, in triplicate, which shall be effective as of the date of filing. No relinquishment of this lease or any portion of the leased area shall relieve the Lessee or its surety from any liability for breach of any obligation of this lease, including the obligation to make payment of all accrued rentals and royalties and to place all wells in the leased lands to be relinquished in condition for suspension or abandonment, and to protect or restore substantially the surface or subsurface resources in a manner satisfactory to the Lessor.

Sec. 24. REMOVAL OF PROPERTY ON TERMINATION OR EXPIRATION OF LEASE

(a) Upon the termination or expiration of this lease in whole or in part, or the relinquishment of the lease in whole or in part, as herein provided, the Lessee shall within a period of ninety (90) days (or such longer period as the Supervisor may authorize because of adverse climatic conditions) thereafter remove from the leased lands, no longer subject to the lease all structures, machinery, equipment, tools, and materials in accordance with applicable regulations and orders of the Supervisor. However, the Lessee shall, for a period of not more than six (6) months, continue to maintain any such property needed in the relinquished area, as determined by the Supervisor, for producing wells or for drilling or producing geothermal resources on other leases.

(b) Any structures, machinery, equipment, tools, appliances, and materials, subject to removal by the Lessee, as provided above, which are allowed to remain on the leased lands shall become the property of the Lessor on expiration of the 90-day period or any extension of that period which may be granted by the Supervisor. If the Supervisor directs the Lessee to remove such property, the Lessee shall do so at its own expense, or if it fails to do so within a reasonable period, the Lessor may do so at the Lessee's expense.

Sec. 25. REMEDIES IN CASE OF DEFAULT

(a) Whenever the Lessee fails to comply with any of the provisions of the Act, or the terms and stipulations of this lease, or of the regulations issued under the Act, or of any order issued pursuant to those regulations, and that default shall continue for a period of thirty (30) days after service of notice by the Lessor, the Lessor may (1) suspend operations until the requested action is taken to correct the noncompliance, or (2) cancel the lease in accordance with Sec. 12 of the Act (30 U.S.C. 1011). However, the 30-day notice provision applicable to this lease under Sec. 12 of the Act shall also apply as a prerequisite to the institution of any legal proceedings by the Lessor to cancel this lease while it is in a producing status. Nothing in this subsection shall be construed to apply to, or require any notice with respect to any legal action instituted by the Lessor other than an action to cancel the lease pursuant to Sec. 12 of the Act.

(b) Whenever the Lessee fails to comply with any of the provisions of the Act, or of this lease, or the regulations, or of any GRO Orders, or other orders, and immediate action is required, the Lessor without waiting for action by the Lessee may enter on the leased lands and take such measures as it may deem necessary to correct the failure, including a suspension of operations or production, all at the expense of the Lessee.

(c) A waiver of any particular violation of the provisions of the Act, or of this lease, or of any regulations promulgated by the Secretary under the Act, shall not prevent the cancellation of this lease or the exercise of any other remedy or remedies under paragraphs (a) and (b) of this section by reason of any other such violation, or for the same violation occuring at any other time.

(d) Nothing herein shall limit or affect the Lessee's right to a hearing and appeal as provided in Sec. 12 of the Act and in the regulations promulgated thereunder.

(e) Upon cancellation, the Lessee shall remove all property in accordance with Sec. 24 hereof, and shall restore the leased lands in a manner acceptable to the Lessor or as may be otherwise required by the Lessor.

Sec. 26. HEIRS AND SUCCESSORS IN INTEREST – Each obligation hereunder shall extend to and be binding upon, and every benefit hereof shall inure to, the heirs, executors, administrators, successors, or assigns, of the respective parties hereto.

Sec. 27. UNLAWFUL INTEREST – No Member of, or Delegate to Congress, or Resident Commissioner, after his election or appointment, either before or after he has qualified, and during his continuance in office, and no officer, agent, or employee of the Department shall be admitted to any share or part in this lease or derive any benefit that may arise therefrom; and the provisions of Sec. 3741 of the Revised Statutes (41 U.S.C. Sec. 22), as amended, and Sections 431, 432, and 433 of Title 18 of the United States Code, relating to contracts made or entered into, or accepted by or on behalf of the United States, form a part of this lease so far as the same may be applicable.

Sec. 28. MONOPOLY AND FAIR PRICES – The Lessor reserves full power and authority to protect the public interest by promulgating and enforcing all orders necessary to insure the sale of the production from the leased lands at reasonable prices, to prevent monopoly, and to safeguard the public interest.

Sec. 29. EQUAL OPPORTUNITY CLAUSE – The Lessee agrees that, during the performance of this contract:

(1) The Lessee will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin. The Lessee will take affirmative action to ensure that applicants are employed, and that employees are treated during employment, without regard to their race, color, religion, sex, or national origin. Such action shall include, but not be limited to the following: employment, upgrading, demotion, or transfer; recruitment or recruitment advertising, layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The Lessee agrees to post in conspicuous places, available to employees and applicants for employment, notices to be provided by the Lessor setting forth the provisions of this Equal Opportunity clause.

(2) The Lessee will, in all solicitations or advertisements for employees placed by or on behalf of the Lessee, state that all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, or national origin.

(3) The Lessee will send to each labor union or representative of workers with which Lessee has a collective bargaining agreement or other contract or understanding, a notice, to be provided by the Lessor, advising the labor union or workers' representative of the Lessee's commitments under this Equal Opportunity clause, and shall post copies of the notice in conspicuous places available to employees and applicants for employment.

(4) The Lessee will comply with all provisions of Executive Order No. 11246 of September 24, 1965, as amended, and of the rules, regulations, and relevant orders of the Secretary of Labor.

(5) The Lessee will furnish all information and reports required by Executive Order No. 11246 of September 24, 1965, as amended, and by the rules, regulations, and orders of the Secretary of Labor, or pursuant thereto, and will permit access to its books, records, and accounts by the Secretary of the Interior and the Secretary of Labor for purposes of investigation to ascertain compliance with such rules, regulations, and orders.

(6) In the event of the Lessee's noncompliance with the Equal Opportunity clause of this lease or with any of said rules, regulations, or orders, this lease may be canceled, terminated or suspended in whole or in part and the Lessee may be declared ineligible for further Federal Government contracts or leases in accordance with procedures authorized in Executive Order No. 11246 of September 24, 1965, as amended, and such other sanctions as may be imposed and remedies invoked as provided in Executive Order No. 11246 of September 24, 1965, as amended, or by rule, regulation, or order of the Secretary of Labor, or as otherwise provided by law.

(7) The Lessee will include the provisions of Paragraphs (1) through (7) of this Section (29) in every contract, subcontract or purchase order unless exempted by rules, regulations, or orders of the Secretary of Labor issued pursuant to Section 204 of Executive Order No. 11246 of September 24, 1965, as amended, so that such provisions will be binding upon each contractor, subcontractor, or subcontract, or purchase order as the Secretary may direct as a means of enforcing such provisions including sanctions for noncompliance: *provided, however,* that in the event the Lessee becomes involved in, or is threatened with, litigation with a contractor, subcontractor, or vendor as a result of such direction by the Secretary, the Lessee may request the Lessor to enter into such litigation to protect the interests of the Lessor.

Sec. 30. CERTIFICATION OF NONSEGREGATED FACILITIES – By entering into this lease, the Lessee certifies that it does not and will not maintain or provide for its employees any segregated facilities at any of its establishments, and that it does not and will not permit its employees to perform their services at any location, under its control, where segregated facilities are maintained. The Lessee agrees that a breach of this certification is a violation of the Equal Opportunity clause of this lease. As used in this certification, the term "segregated facilities" means, but is not limited to, any waiting rooms, work areas, rest rooms and wash rooms, or restaurants or other eating areas, time clocks, or locker rooms, and other storage or dressing rooms, parking lots, drinking fountains, recreation or entertainment areas, transportation, and housing facilities provided for employees which are segregated by explicit directive, or are in fact segregated on the basis of race, color, religion, or national origin because of habit, local custom, or otherwise. Lessee further agrees that (except where it has obtained identical certifications from proposed contractors and subcontractors for specific time periods) it will obtain identical certifications from proposed contractors and subcontractors prior to the award of contracts or subcontracts exceeding $10,000 which are not exempt from the provisions of the Equal Opportunity clause; that it will retain such certifications in its files; and that it will forward the following certification to such proposed contractors and subcontractors (except where the proposed contractor or subcontractor has submitted identical certifications for specific time periods); it will notify prospective contractors and subcontractors of requirement for certification of nonsegregated facilities. A Certification of Nonsegregated Facilities, as required by the May 9, 1967 Order (32 F.R. 7439, May 19, 1967) on Elimination of Segregated Facilities, by the Secretary of Labor, must be submitted prior to the award of a contract or subcontract exceeding $10,000 which is not exempt from the provisions of the Equal Opportunity clause. The certification may be submitted either for each contract and subcontract or for all contracts and subcontracts during a period (i.e., quarterly, semiannually, or annually).

Sec. 31. SPECIAL STIPULATIONS – *(stipulations, if any, are attached hereto and made a part hereof)*

In witness whereof the parties have executed this lease.

Lessee:

(Signature of Lessee)

(Signature of Lessee)

[SEAL] (Date)

THE UNITED STATES OF AMERICA, Lessor:

By ____________________

(Authorized Officer)

(Title)

(Date)

GPO 883-471

APPENDIX L. SELECTED REFERENCES

Allison, J.L., and D.H. Green, 1974, Idaho's gateway to Yellowstone—the Island Park story: Island Park—Gateway Publishing Co.

Arbib, R., 1977, The blue list for 1978: American Birds, vol. 31, #6, pgs. 1087-1096.

Canter, L.W., 1977, Environmental impact assessment, McGraw Hill Book Co.

EDAW, Inc., 1977, Island Park geothermal energy development—social and economic assessment: EDAW, Inc., Ft. Collins, Colorado.

Flath, D.L., 1978, Nongame species of special interest or concern: mammals, bids, reptiles, amphibians, fishes: Wildlife Division, Montana Dept. of Fish and Game.

Hamilton, W., 1960, Late Cenozoic tectonics and volcanism of the Yellowstone region, Wyoming, Montana and Idaho, in Billings Geological Society, 11th Annual Field Conference, 7-10 Sept. 1960, West Yellowstone earthquake area, p. 92-105.

1965, Geology and petrogenesis of the Island Park Caldera of rhyolite and basalt, eastern Idaho: US Geological Survey Professional Paper 504-C.

Keefer, W.R., 1971, The geologic story of Yellowstone National Park: US Geological Survey Bulletin 1347.

Kruger, P and C. Otte, 1973, Geothermal energy-resources, production, stimulation: Stanford Univ. Press.

Love, J.D., 1956, Geologic map of Teton County, Wyoming in Wyoming Geological Association, Jackson Hole Field Conference Guidebook.

Pacific Northwest River Basins Commission, 1970, Columbia-North Pacific Region framework study of water and related lands, Appendix V—Water Resources

Peterson, D.L., and I.J. Witkind, 1975, Preliminary results of a gravity survey of the Henrys Lake quadrangle, Idaho and Montana: US Geological Survey Journal of Research, vol. 3, #2, p. 223-228.

Phillips, K.J., and J.A. De Filippi, 1976, A matrix approach for determining wastewater management impacts: Journal of Water Pollution Control Federation, vol. 48 #7, pgs. 1759-1765.

Rocky Mountain Mineral Law Foundation, 1977, Proceedings, Geothermal resources development institute.

Rowe, J.J., R.O., Fournier, G.W. Morey, 1973, Chemical analysis of thermal waters in Yellowstone National Park, Wyoming, 1960-1965: US Geological Survey Bulletin 1303.

State of Idaho Fish and Game Dept., 1978, A plan for the future management of Idaho's fish and wildlife resources, volume 1: goals, objectives and policies, 1975-1999.

State of Wyoming Game and Fish Dept., 1977, Current status and inventory of wildlife in Wyoming.

Trewartha, Glenn T, 1965, An introduction to climate: McGraw Hill Book Co., NY.

US Dept. of Agriculture, Rural Electrification Administration, 1975, Suggested practices for reducing raptor losses on powerlines: Bulletin.

1975, Powerline contacts by eagles and other large birds: Bulletin 61-10.

US Dept. of Commerce, 1973, Monthly normals of temperature, precipitation, and heating and cooling degree days, 1941-1970, for Idaho and Montana.

US Environmental Protection Agency, 1977, Approval and promulgation of state implementation plans, subchapter C, air programs: Federal Register, vol. 42, #212, Nov. 3, 1977, p. 57459-57461.

US Forest Service, 1976, Final environmental statement and land management plan, west slope of the Tetons planning unit, Targhee National Forest

US Forest Service, 1978, Final environmental statement and land management plan, Island Park planning unit, Targhee National Forest

1978, Draft environmental statement, geothermal leasing and development on part of the Gifford Pinchot National Forest.

1978, Final environmental statement, geothermal development Breitenbush area, Willamette and Mt. Hood National Forests.

US Dept. of the Interior, Bureau of Sports Fisheries and Wildlife, 1973, Threatened wildlife of the US (Red Book)

US Dept. of Transportation, 1974, Standard specifications for construction of roads and bridges on federal highway projects, FP-74.

US Geological Survey, 1964, The Hebgen Lake, Montana earthquake of August 17, 1959; US Geological Survey Professional Paper 435.

US Geological Survey, 1976, Water Resources Data for Idaho, Water Year 1975.

Whitehead, R.L., 1978, Water resources of the upper Henrys Fork basin in eastern Idaho: Water Information Bulletin No. 46, State of Idaho Dept. of Water Resources.

Witkind I.J., P.A. Hoskins, V.L. Lindsey, and E.L. MItchell, 1972, Folio of the Henrys Lake Quadrangle, Idaho, Montana: US Geological Survey map I-781-A, C, D, E, and I.

Witkind, Irving J., 1975, A proposed glacial history of the Henrys Lake Basin, Idaho: Journal of Research of the US Geological Survey, vol. 3, #1, p. 67-76.

APPENDIX M. SIGNIFICANT CONTRIBUTIONS TO THE ENVIRONMENTAL STATEMENT PROCESS WERE RECEIVED FROM THE FOLLOWING PEOPLE:

Name	Qualification
U.S. Forest Service	
Boise National Forest	
Ted Mullin	Geologist
Gallatin National Forest	
Claude Coffin	Supervisory Forester
Phil Cowan	Energy Coordinator
Carl Davis	Soil Scientist
Steve Glasser	Hydrologist
Jerry Light	Wildlife Biologist
Ralph Meyer	District Ranger
John Sandmeyer	Long Range Planner
National Forests in Texas	
Dale Bounds	Visual Information Specialist
Sawtooth National Recreation Area	
Harry Young	Geologist
Shoshone National Forest	
Steve Mealey	Wildlife Biologist
Targhee National Forest	
Bart Andreasen	Landscape Architect
Mickey Beland	Resource Coordinator
Craig Cortwright	Silviculturalist
Robert L. Davis	Hydrologist
John Ferebauer	Economist
Larry Gorringe	Engineer
Dave Griffel	Wildlife Biologist
Richard Heninger	Forester (minerals)
Wayne Jenkins	Forestry Technician
Sara J. Johnson, Ph.D.	Wildlife Biologist
Mark Kary	Range Conservationist
John M. McGee, Ph.D.	Wildlife Biologist
Timothy Murphy	Archaeologist
Paul Oakes	Soil Scientist
George Olson	Forest Supervisor
Ned Pence	District Ranger
Gary Rahm	District Resource Assistant
Robert Riley	Forester (timber)
Stan Szczepanowski	Hydrologist
Robert Williams	Planner
Marvin Wolfe	Silviculturalist
Dave Winn Ph.D.	Wildlife Biologist
U.S. Geological Survey	
Robert L. Christiansen, Ph.D.	Geothermal Research Program Coordinator
David Fach	Physical Scientist
Robert Kent	Environmental Scientist
Robert Lewis	Hydrologist
Donald E. White, Ph.D.	Geologist
Richard L. Whitehead	Hydrologist
Bureau of Land Management	
Doug Causey	Geologist
Gale Green	Forester
Dave Kissel	Landscape Architect
Doug Stone	Economist
Marc Whiser	Range Conservationist

National Park Service (Yellowstone National Park)
Edmund J. Bucknall. . . . . Resource Management Specialist
Roderick Hutchinson. . . . . Geologist
Richard Knight, Ph.D. . . . . Project Leader, Interagency Grizzly Bear Study Team
Mary Meagher, Ph.D. . . . . Chief Research Biologist

U.S. Fish and Wildlife Service
Richard Howard. . . . . Wildlife Biologist
Robert Rainville. . . . . Fisheries Biologist

Department of Energy
Robert Chappell. . . . . Project Engineer
John Griffith. . . . . Chief of Research and Engineering
Susan Spencer. . . . . Environmental Engineer

State Agencies:

Wyoming

Game and Fish
John Erickson. . . . . Fisheries Biologist
Harry Harju, Ph.D. . . . . Staff Biologist for Environmental Affairs
Garvice Roby. . . . . Wildlife Biologist
Michael Stone. . . . . Staff Fisheries Biologist

Montana

Fish and Game
Dennis Flath. . . . . Head, Northern Rocky Mountain Wolf Recovery Team
Arnold Foss. . . . . Regional Game Manager
Dick Vincent. . . . . Fisheries Biologist

Bureau of Mines and Geology
John Sonderegger. . . . . Hydrogeologist

Idaho

Fish and Game
Joe Curry. . . . . Conservation Officer
Frank DeShon. . . . . Assistant Regional Game Manager
Paul Jeppson. . . . . Regional Fisheries Biologist
Bruce Penske. . . . . Conservation Officer
Tom Reinecker. . . . . Regional Supervisor
Brent Ritchie. . . . . Big Game Biologist
Robert Sherwood. . . . . Regional Game Manager
Greg Tourtlotte. . . . . Conservation Officer

Dept. of Parks and Recreation
Bill Hagdorn. . . . . Chief, Planning Division

Individuals

Remington Kohrt. . . . . Forester (Industrial)
Monte Later. . . . . Merchant
Jerry Reynolds. . . . . Magistrate, Fremont County, Idaho
Robert Smith Ph.D. . . . . Geophysicist, Univ. of Utah